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RECENT IMPROVEMENTS INTRODUCED INTO THE MANUFACTURE OF GAS.

SINCE the beginning of the present century, the gas industry has made but slight progress. However, since the electric light has come into competition with this most generally adopted mode of lighting, manufacturers of gas have been endeavoring to reduce the price of the latter, while at the same time keeping intact the dividends paid to the stockholders. In order to do this, it has become necessary to introduce improvements into the process of manufacture.

One of the most important apparatus in gas manufacture is the retort furnace, for upon the construction of this depends the quantity of gas produced and the yield of coke. In former times, many gas works used their coke for heating the retorts, and there were even some that were obliged to buy foreign coke. At present, thanks to the application of the Siemens regenerator, the consumption of coke has diminished by more than one-half, and at Munich but 15·77 per cent. is used—say 9·5 per 100 kilogrammes (220 lb.) of the coke put into the furnace,

The Munich furnace (Schilling & Bunte system), which is represented in Fig. 1, is a nine-retort one. The generator, which is of peculiar form, is situated in front of and beneath the furnace, its hopper being on a level with the surface of the earth. The gases produced escape into two parallel conduits between the retorts, and descend, between the last row and the walls, into a series of quincuncial channels that alternate with the conduits through which the combustive air enters The currents of combustive air and burned gases are reversed, and the mixing of the combustive air with oxide of carbon takes place in a small combustion chamber situated in the center of the furnace.

After heating the air by conductivity through the sides of the flues, the burned gases heat a reservoir of water situated beneath the grate. The steam produced flows into the gas generator along with a current of air led by a pipe whose discharge is accurately regulated. The great thickness of the walls surrounding the free space left between the two arches is a feature of construction of prime importance as regards saving of fuel.

The furnace devised Mr. Hasse, of Dresden, is similar to the one just described, and constitutes therewith one of the most marked progresses that have hitherto been made in the manufacture of gas.

Figs. 2 and 3 represent a type adapted for small works. In this six-retort furnace the gas generator is situated above ground and between the retorts. The other details are nearly like those of the preceding furnace.

For closing the retorts, the device now generally used is Merten's, which is shown in Fig. 4. The hinged door is fastened by means of a lever provided with an eccentric.

As regards the hydraulic main, the continual increase in the temperature at which the distilling is effected (and which carries into this apparatus a thick tar that readily clogs the pipes) has led to important modifications.

The Dresden hydraulic main (devised by Mr. Hassé) is shown in Figs. 5 and 6. It is only necessary to inspect the latter to see how the apparatus works.

As for condensers, we shall mention the well-known one of Messrs. Pelouge & Audouin, which, up to the present, has given excellent results.

The most remarkable modification in exhausters consists in the use of three instead of two valves (Fig. 7), thus securing a more regular motion in the suction of the gas.

Among scrubbers, we must mention Kirkham's (Figs. 8 and 9), which performs the office of the old Walker tower, and takes up much less space. It consists of a semi-cylindrical reservoir divided by transverse partitions into compartments that contain, each of them, a series of parallel round plates having an aperture in the center. The gas enters through these apertures, and, in order to reach the succeeding compartment, has to traverse the upper part of the series of plates, which are kept constantly wet by the water that they carry along in their five or six revolutions per minute.

Finally, we must describe the principle of the Blum & Gruneberg exhauster (Fig. 10), which unites in a single apparatus the various complicated ones that were formerly employed. The ammoniacal waters that enter above fall in a cascade through small notched bells, and meet a current of steam which is flowing in the opposite direction. A union takes place in the central reservoir, R, which contains milk of lime. All the ammoniacal compounds that the heat has been unable to destroy become decomposed. The water afterward descends to the lower part of the apparatus, where it becomes hotter and hotter under the influence of the current of steam that debouches there, and reaches the bottom entirely free from ammonia. This apparatus advantageously replaces the complicated ones of Mallet, Rose, Ludge, and others.

As regards gasometers, we would mention that of Intze (Fig. 11). The well of this has a dome-shaped bottom, and is of metal. The reservoir, which thus holds less water, is supported by masonry.

Figs. 12 and 13 represent the Baumert valve, an apparatus which, by the simple maneuver of a screw, permits of isolating any one of the apparatus of a gas works.

Among burners, we may mention that of Westphal (Fig. 14). In this apparatus the gas enters through a double branch (which serves at the same time for suspending the burner), and flows to the lower part, to feed the flame. The products of combustion rise in the central chimney and pass into a regenerator before making their exit. The smallest type gives a from 30 to 33 candle power with a consumption of from 7 to 8 cubic feet of gas.—*Annales Industrielles.*

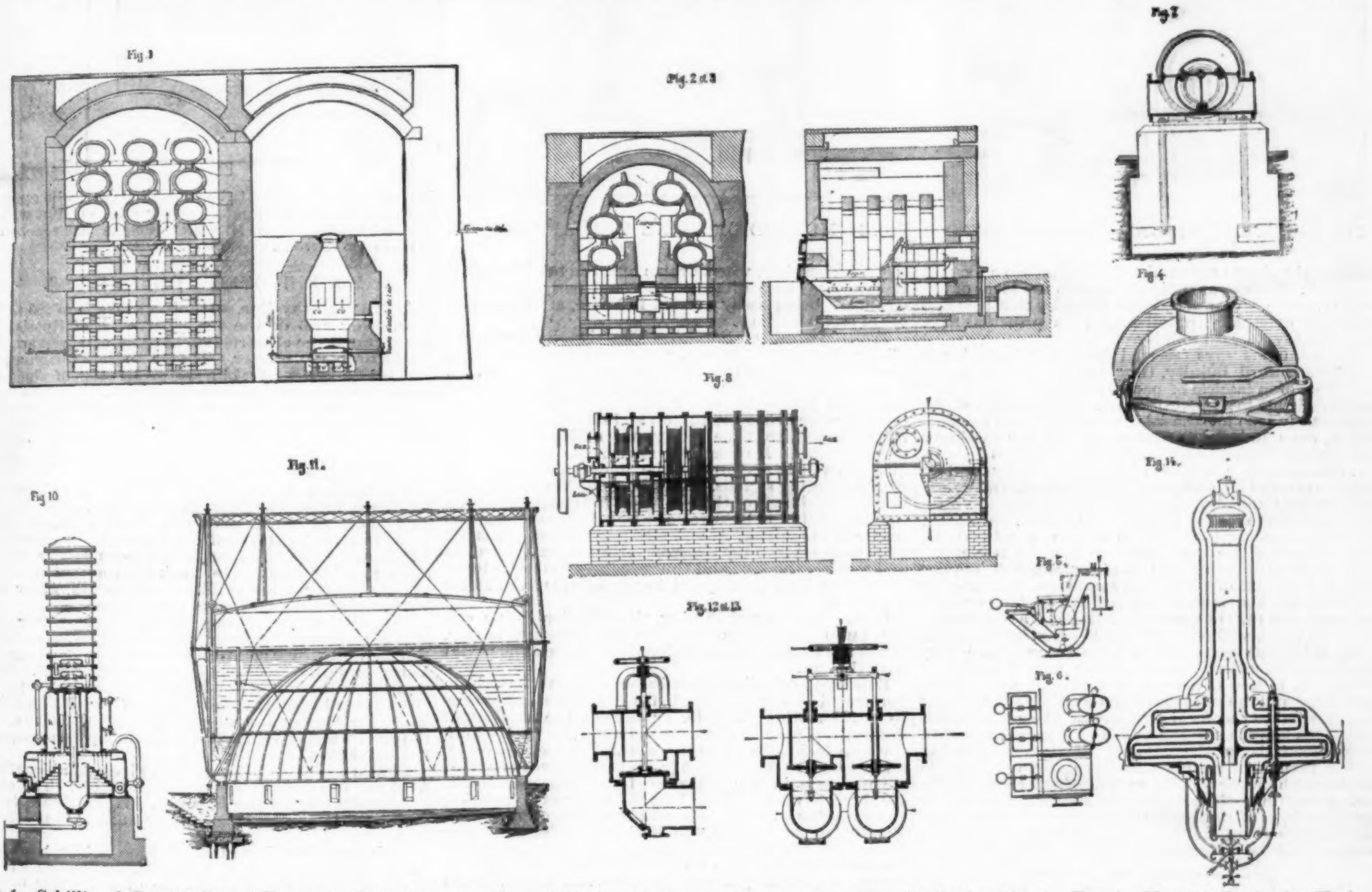


FIG. 1.—Schilling & Bunte's Retort Furnace. FIGS. 2 AND 3.—Hasse & Vacherot's Furnace (transverse and longitudinal sections). FIG. 4.—Merten's Device for Closing Retorts. FIGS. 5 AND 6.—The Dresden Hydraulic Main. FIG. 7.—Exhauster. FIGS. 8 AND 9.—Kirkham's Scrubber. FIG. 10.—Blum & Gruneberg's Exhauster. FIG. 11.—Intze's Gasometer. FIGS. 12 AND 13.—The Baumert Valve. FIG. 14.—Westphal's Gas Burner.

RECENT IMPROVEMENTS IN THE MANUFACTURE OF GAS.

GAVOY'S OPTICAL SIGNALING APPARATUS.

THE Mangin apparatus for optical telegraphy are very ingenious, and are rendering many important services to the army. The large size, which is of considerable weight and bulk in proportion to its great power, is designed for use in strongholds, while the small size, which may be carried on a man's back, and which is supported by a tripod, is used for transmitting signals during campaigns. This latter is still too heavy, as it weighs 77 pounds. The man whose duty it is to operate it cannot easily change his place, and he cannot follow all the events of a battle, nor, with the instrument on his back, rapidly walk over ground that has been plowed or been wet with rain. The new arrangement of troops for fighting, and the new tactics, require that a scout situated in a given place shall be able to signal every peculiar incident instantaneously; that a cavalry officer on a reconnaissance shall, despite distance, have the power of keeping himself in contact with the general-in-chief, and of directly communicating to him the results of his exploration; and that the commander-in-chief of the army corps shall be able, like an admiral, to send his orders to every echelon with the greatest celerity.

Optical or luminous signals are the most apparent, are most easy to direct, and are after a manner instantaneous. An optical instrument that was light, convenient, compact, easily maneuvered, re-

quired no focusing, and was easily placed in a saddle-bag or the pocket, would, then, fulfill the required conditions. Such conditions are, I think, found united in a small instrument which I call the "Optical Signaler." This consists, theoretically, of a plane mirror, A, movable around an axis, *a*. Above this there is a second mirror, B, which is fixed, and inclined at an angle of 45°. This mirror is placed opposite a system of vertical lenses, D D'. One of these latter, D, is plano-convex, while the other, D', is convexo-convex. The apices of the cones formed by the convergent fascicles coincide at the point, F. The solar rays reflected by the mirror, A, are deflected by B, and projected upon the plane face of the lens, D, which re-

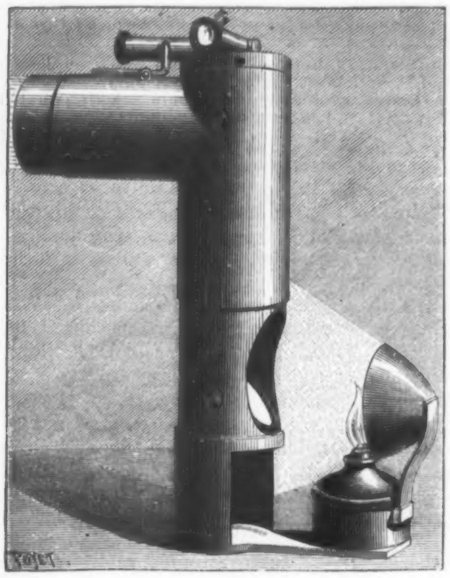


FIG. 1.—POCKET SIGNALING APPARATUS.

fracts the luminous rays and unites them into a focus at the point, F. But, as this point is also the focus of the lens, D', these rays are caught anew by this lens and projected externally, parallel with its principal axis, that is to say, toward infinity.

The luminous rays received by the mirror, A, are projected toward infinity, then, by the lens, D', under the form of a fascicle of parallel rays, and are consequently visible to a great distance. This theory, which is absolutely true for the solar rays that reach the mirror, A, from infinity, is not exact for the luminous rays emanating from a source a few centimeters distant, say, for example, a kerosene lamp. These rays will no longer converge into a focus at the point, F, and consequently their emission will not be parallel with the principal axis of the lenses, unless the lens, D', be moved, and an endeavor be made to obtain a coincidence of the apices of the cones of the convergent fascicles.

In order to do away with maneuvers which require time and are out of place on a campaign, and in order to render the instrument adapted for working equally well with the rays of the sun or those of a candle or a kerosene lamp, without any modification of the apparatus, it became necessary to have recourse to a very simple combination. To the lower face of the plane mirror, A, is added a concave mirror of a calculated curvature, and the lamp moves upon a slide of a constant length equal to the focal distance of the concave mirror. This lamp is surmounted by a concave reflector, whose focus is in the flame of the lamp. A spiral spring permits of raising the lamp to a determinate height, with respect to the center of the concave mirror. As a result of these various combinations, based upon the laws of optics, the luminous rays emitted by the kerosene lamp, and concentrated upon the concave mirror, will be reflected by the latter in a fascicle of

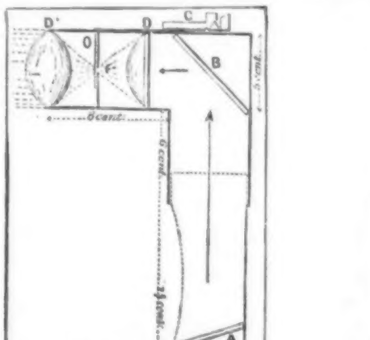


FIG. 3.—SECTION SHOWING DETAILS.

parallel rays toward the plane mirror, B, and (important point) will form their focus at the point, F, as do the solar ones. Their emission through the lens, D', then, will be parallel with the principal axis.

The apparatus is thus regulated for operating with the sun or a lamp indifferently—a very important matter on a campaign, from more than one point of view.

The Apparatus.—The optical signaler is formed of two copper tubes, 2 inches in diameter, sliding one within the other as do those of a telescope. The upper tube contains a plane mirror, B, having an aperture in the center, and receives, at right angles, a copper tube that contains two lenses, DD', and supports a small finder, C, and an intercepter. This latter is a sort of key that lifts or depresses a strip of metal, O, that slides in front of the aperture in a diaphragm placed in the focus of the two lenses. The signals are extremely rapid and very easily made.

The lower tube carries a plano-concave mirror, A. Beneath this stands a small kerosene lamp with an asbestos wick, capable of burning for ten hours. This lamp is fixed by a bayonet catch to a slide that permits of its being pulled out. Finally, the wick-holder elongates so as to bring the flame to the definite height that it is to occupy.

When one tube is pushed into the other, the length

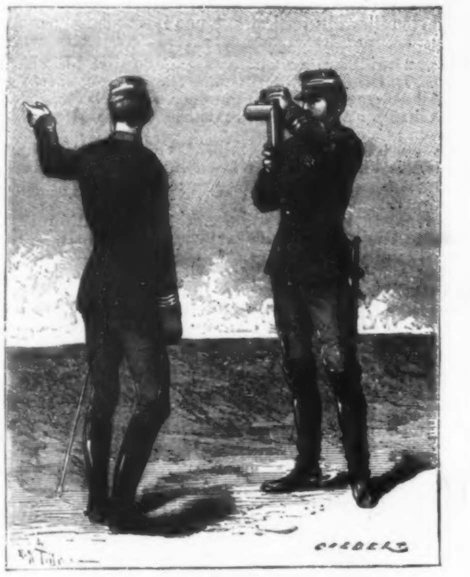


FIG. 2.—METHOD OF USING THE APPARATUS.

is 4½ inches, but, when drawn out, the total length is 11 inches. These dimensions would permit of the instrument being easily carried in a case, after the manner of an opera glass.

Transmission of Signals.—The signaler turns the mirror, A, toward the sun, and revolves the button, *a*, until he perceives the luminous rays in the lens, D'. Then he takes the apparatus in one hand by the lower tube, and places the other hand upon the upper tube in such a way that the thumb and last two fingers surround it, and that the index and middle finger rest upon the key. He raises the apparatus to a level with his face, and looks through the finder for the person who is sending signals. As soon as he has found him, he assures himself of the existence in the telescope of a small scintillating light formed by a ray traversing the center of the mirror, A, and striking the base of a small glass cone set into the telescope. He alternately presses and releases the key, and thus produces flashes or luminous lines that correspond to the letters of the Morse alphabet.

If the sun be not shining, the signaler draws out the lamp slide, turns back the plano-convex mirror, lights the lamp, and sends signals the same as he would with the sun.

Experiments in the transmission of signals have been performed in Versailles Park, from the basin of Neptune to Saint Anthony's Gate, or toward the plateau of Satory, to distances of from a thousand to twelve hundred yards, just to verify the working of the apparatus, and without seeking its range, and some have been tried with success in the presence of army officers. Baron Nugues, to whom I have had the honor of submitting the apparatus, has given a most favorable opinion of it. Finally, at my request, the Minister of War in a letter dated Oct. 28, 1885, has been good enough to authorize the presentation of the instrument to the Committee on Military Telegraphy.—*Dr. E. Gavoy, in La Nature.*

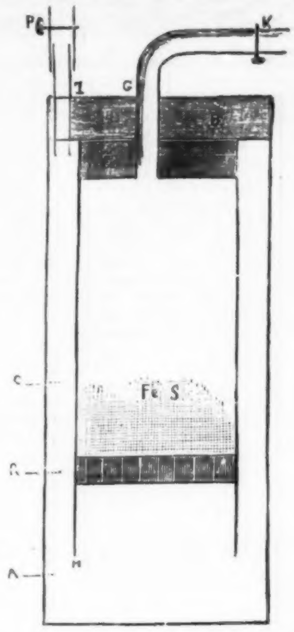
ON A NEW SULPHURETED HYDROGEN GAS APPARATUS.

By JOHN J. BARLOW.

THE following is a drawing, with explanation in detail, of a sulphureted hydrogen gas apparatus which I have been using now for some time, which works well, is simple and easy to make, and does not cost much, and I can by its means always have ready a supply of gas; nor does it give off any offensive odor.

A is a large jar, about 10 inches high and 3 inches in diameter; it is closed at the mouth with a very tight fitting stopper, B, of India rubber cut out of ¾ inch thick sheet rubber; if this is not to be had, a good sound cork pushed in tight, about ⅛ inch below the top of the jar, and then well covered with wax or paraffin. Inside this jar, and fitting close up underneath the stopper, B, is a strong wide tube, about 8 inches long and 2½ inches in diameter, C. The top end of this tube is also provided with a very tight-fitting stopper. A strong glass tube, G, ¼ inch in diameter, passes through both of these two stoppers, one end just protruding about ⅛ inch below the inner stopper; the other end, outside and above the outer stopper, is bent around at right angles, and is connected with a piece of rubber tubing which is provided with a strong clip, K. This tube, G, serves for the exit of the gas, and also supports the inner jar, or tube, C; R is a perforated cork, pushed up 1 inch inside the inner tube, C; this cork supports the iron sulphide, FeS; *t* is a glass tube passing through the stopper of the outer jar, and is provided with a piece of rubber tubing and clip, P.

To work the apparatus, take out the inner tube, then place the FeS inside the inner jar, and resting on R; then place the tube, C, inside the jar, A, pressing down the stopper, B; open G by means of the clip, K, remove the India-rubber tubing from *t*, then insert a small funnel in the tube, *t*, and pour in, and, filling the jar to within ⅛ inch of the stopper, B, with dilute H_2SO_4 (1 : 6), remove the funnel; slip on the rubber tube. Now open both clips, when the acid will rush up inside the inner vessel; close the tubes, G and *t*; gas will now form, and will fill the tube, C, and at last by its own pressure push out the acid liquid down as far as M, when the action will cease until a supply of gas



is required, when the tube, G, will have to be opened, and the liquid will again rush up into C, but will be pushed back again to M, when the gas has reached a certain pressure in C.—*Chem. News.*

BRIDGE OVER THE DNIEPER.

A NEW railway line, of a total length of 285 miles, connecting two of the principal roads of Russia, has necessitated the construction of some very remarkable works over the Dnieper. These two lines terminate at Nicolaief and Sebastopol respectively, two of the most important centers upon the Black Sea. The new road that connects them crosses the district of Jekaterine. The construction of this new line has necessitated the building, among other things, of a viaduct over a wide and deep ravine that forms the bed of the Juquletz River and of a bridge over the Dnieper.

The viaduct is remarkable for its height above and its depth below the level of the water. Its piers exceed those of the London structure by 22 feet. It is 1,050 feet in length, and consists of five arches upon which are established non-continuous lattice girders and a parabolic one. The track is on a level with the upper platbands, and is 156 feet above low water and 222 feet above the bottom of the caisson.

The dimensions of the bridge thrown over the Dnieper are much greater. Its length is exceeded in Europe only by the Alexandrowsky bridge over the Volga and the Moerdyck bridge in Holland. The position of this work, and chiefly its proximity to the city situated upon the right bank of the Dnieper, has led to the construction of a bridge with two floors, the upper of which is for carriages and foot passengers, and the lower for the railway.

Fifteen spans of 274 feet each give a total length of 4,110 feet from one abutment to the other. The clear height above low water is 43 feet. This distance is reduced to 14 feet at high water such as was seen in 1845.

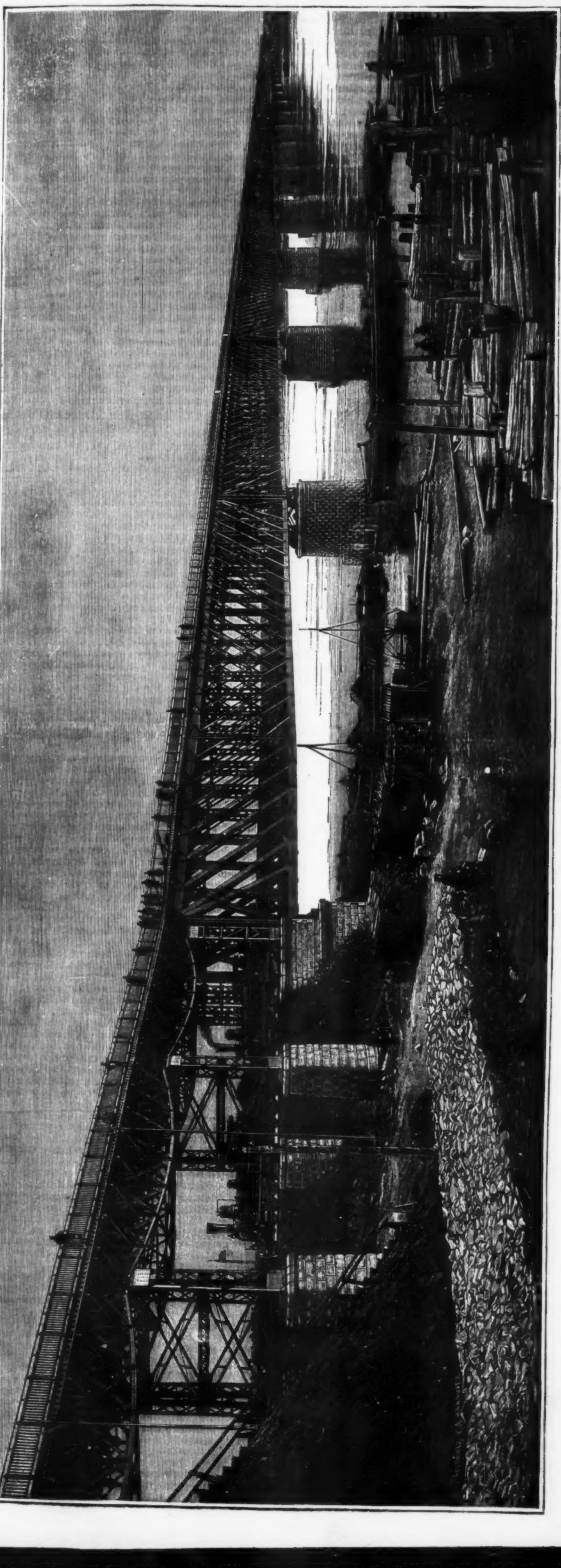
Each span consists of 23 divisions. The roadway, between and outside of the rails, is provided with a flooring. Solid counter rails are placed inside of the track. Timbers 29 feet in length support the carriageway, whose level is 30 feet above that of the rails, which are themselves supported by timbers 4 feet in length. The carriageway slopes gently on each side of its axis, and is provided with gutters to carry off rain water.

From a geological standpoint, the river bed consists of a stratum of granite covered with a thin layer of sand that overlies a sandy and a white clay. The granite reaches the surface only upon the right bank, and is there very thick. The right abutment and the first pier are therefore built upon rock. In constructing this pier there was used, for the first time in Russia, a diving-bell like the one employed for the Copenhagen bridge. This apparatus, whose plane exactly corresponded to that of the piers, and which was afterward used as a caisson for pier No. 4, was let down to the rock. In measure as the foundation rose, the bell was raised until the masonry had reached the surface. All the other piers are built upon caissons that rest partially upon the rock and partially upon the white clay. The mean depth to which the piers descend is 50 feet, and the fourteenth, which is the highest, reaches a depth of 57 feet. All the masonry of the piers is of granite, taken from the shore near the bridge. The piers are 15¾ feet in width at the base and 12 feet at the apex, and are 50 feet in height.

The bridge is prolonged at each extremity by a viaduct, composed of three spans of parabolic girders.

These viaducts intersect the bridge at an angle of 21 degrees. They connect the carriageway with the highway, and allow the railway to follow a rectilinear direction. The accompanying figures show the arrangement of these approaches. With these viaducts included, the total length of the bridge is 4,590 feet.

Into the construction of the bridge there enter 883,000 cubic feet of masonry and 3,280 tons of Portland cement. The latter was used in the proportion of 1 to 4 in the open air work and of 1, to 3 in the submarine



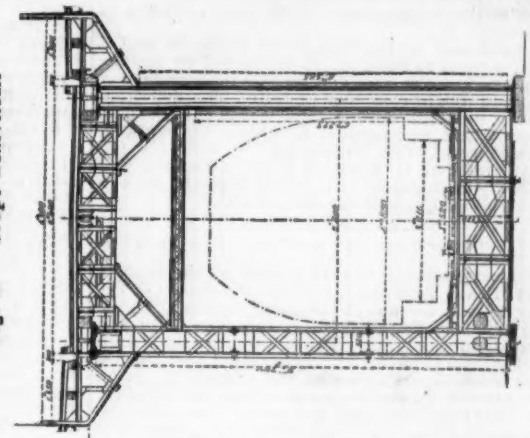


Fig. 3. — Coupe transversale

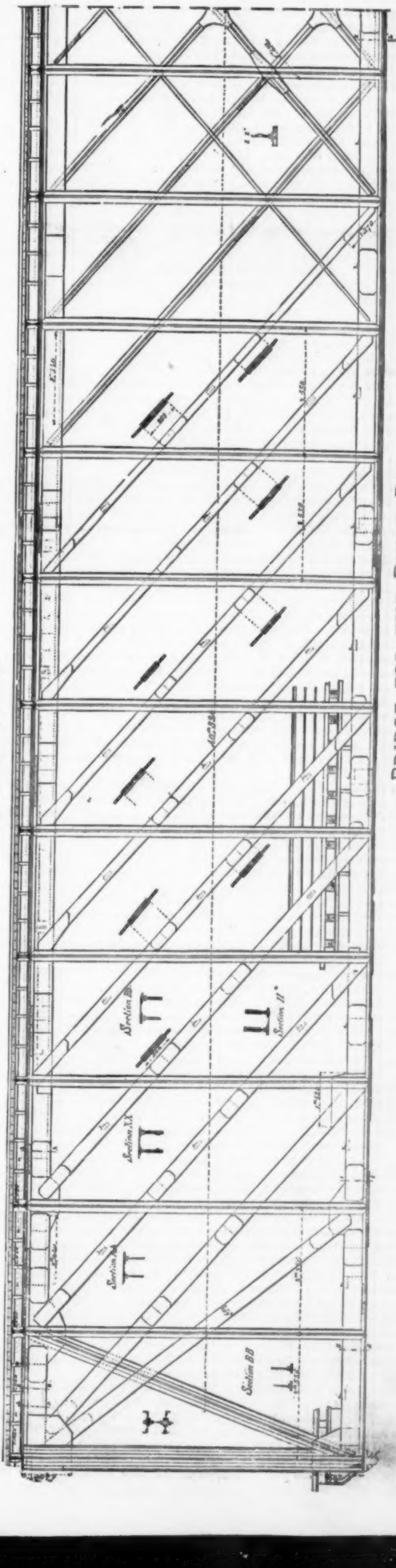


FIG. 2.—ELEVATION.

BRIDGE FOR THE RIVER DNIEPER.

portion. The ironwork, which was furnished by the Brjonsk works, weighs nearly 10,000 tons, exclusive of the caissons.

The total cost of the bridge was $1,950,000, and it took three years to build it. It was tested by placing 8 locomotives on the rails, and loading the carriageway with a dead weight composed of rails. The deflection did not exceed $\frac{1}{2500}$ of the total length of each span. This important construction is wholly the work of Prof. Belelubsky, of St. Petersburg. It was built under the direction of Engineer in Chief Beresin, who had already distinguished himself in Russia by important work on bridges.—*Revue Industrielle.*

THE INSTITUTION OF NAVAL ARCHITECTS.

THE twenty-seventh annual session of the Institution of Naval Architects, held at the rooms of the Society of Arts, was one of the most successful of the series. The meetings began on the 14th April and concluded on the 17th. There were seven sittings, averaging from three to four hours each, and no less than eighteen papers were read and discussed. As on previous occasions, too much was attempted to be done in the time available, with the result that some important matters received scant notice. This may be to some extent inevitable in a society embracing such wide and varied interests, yet meeting but once a year. But it may be anticipated that the autumn meetings in the outports which are now contemplated may somewhat relieve the congestion in future.

Lord Ravensworth presided, as usual, and delivered a Presidential Address, in which various matters of interest were touched upon, *inter alia* the use of liquid fuel instead of coal in steamships, the development of triple-expansion engines, the prospects of shipping and the statistics of shipbuilding, including the extended use of steel. It may be hoped, although the immediate future scarcely justifies the expectation, that before the next meetings a change in circumstances may enable the President to speak more cheeringly. On the other hand, it is an undoubted fact that the period of depression through which the country is now passing is forcing into prominence inquiries into possible economies in the construction and propulsion of ships which might otherwise have been neglected.

No less than seven of the papers read had relation to the propulsion of steamships. The first on the list —"On the Speed Trials of Recent War-Ships"—was read by Mr. W. H. White, Director of Naval Construction. It contained a succinct account of the remarkable advances made during the last quarter of a century in the speeds and propelling machinery of war-ships. The fact that huge battle-ships carrying enormous weights of armor and guns are now driven at speeds of 17 to 18 knots—20 to 21 miles per hour—is sufficiently remarkable. Yet the fact that such a ship, weighing 10,000 tons, can be driven 9 knots in an hour with an expenditure of only one ton of coal is no less striking. Much has been learnt, too, of late years as regards the influence of *form* upon the resistance of ships—thanks, in great measure, to the researches of the late Mr. Froude, whose work received the substantial support of the Admiralty. In the paper above mentioned it was shown that by suitable selection of form, the Howe, a vessel of 9,600 tons, 325 feet long and 68 feet broad, was driven as easily as the Warrior up to the highest speed reached by the latter, although she was 380 feet long, 58 feet broad, and of 8,850 tons only. The Warrior reached 14½ knots only; the Howe attained 17 knots. Improvements in marine engineering made this tremendous speed possible in the Howe. In her, each ton weight of propelling apparatus corresponded to 10 indicated horse-power; in the Warrior 6 indicated horse-power required 1 ton. This economy of weight in the propelling apparatus was shown to be due to several causes, including a higher steam-pressure, quicker-running engines, the use of forced draught in the stoke-holds, and the introduction of wrought iron, steel, and gun-metal instead of cast iron.

Two papers dealt with the interesting subject of "forced draught" from different points of view. Mr. Sennett described at some length the Admiralty system of "closed stoke-holds," by means of which air is delivered into the boiler-rooms by powerful fans, and at a sensible pressure. The stoke-holds being thus *in plenum*, the air can escape only through the furnaces, and combustion is quickened greatly. With the best *natural* draught, about 10 indicated horse-power per square foot of furnace (or grate area) is considered a good performance; with forced draught and closed stoke-holds, this may be increased from 60 to 80 per cent. It will be seen therefore that for war-ships, which only require to steam occasionally and for comparatively short periods at full speed, the system is admirably well adapted. And it has been proved to be not nearly as wasteful of fuel as might have been supposed; while it certainly makes the stoke-holds cooler and more comfortable to work in. For the mercantile marine the conditions are different; ships have to steam ordinarily at practically their full speed; the restrictions of weight and space are not so great as in war-ships; and economy in coal consumption is of primary importance. Still even here forced draught promises to supplant natural draught, and to enable large economies to be made in weight and size of boilers concurrently with savings in coal. Mr. Howden described his system of forced combustion, which has been tried at sea over a long period, and promises to be successful. He does not close in the stoke-holds, but delivers air under pressure from fans direct into the furnaces and ash-pits, this air having been heated by passing through a special apparatus placed in the uptakes. Great economy is claimed for this system, and it was well spoken of by competent authorities in the discussion which followed. Competing plans are also being tried, so that more will certainly be heard of forced draught in the mercantile marine. Hitherto economy has been sought in higher pressures and in the *use* of steam in the engines; now engineers are turning attention to the boiler, and the means of generating steam with a minimum expense.

Hard times in the mercantile marine have led to a wholesale conversion of compound engines into engines of the triple or quadruple expansion type. Mr. Cole read a thoughtful and well-considered paper on this subject, which is of general interest to ship owners just now. It may prove a very desirable thing to reduce the coal-bill by 20 per cent., even at the cost of converting the machinery to the more highly expansive type.

It is a natural transition from the propelling machinery to the propellers of steamships. Mr. R. E. Froude, who has succeeded his father in the superintendence of the Admiralty model-experimental works, contributed one of the most valuable and scientific papers read at the meetings, on "The Determination of the Most Suitable Dimensions for Screw Propellers." He attempts from experiments with models of ships and screws to ascertain the resistance experienced by a ship moving at a given speed, and the "augment" of that resistance produced by the action of the propeller behind her. By means of a lengthy series of experiments with model screws he further attempts to fix the best diameter and pitch for a given number of revolutions of the engines. And finally, the results are thrown into a form adapted for practical use. The paper is in all respects admirable, but we are bound to say that it can be regarded only as another step forward on a very difficult road, and may be treated as provisional rather than conclusive. Some of the inferences do not accord, either, with the results of general experience. It is to be welcomed, however, for as yet the theory of the screw propeller is not in a satisfactory condition; and it is well known that very remarkable economies are frequently realized by changes in propellers. In the course of the discussion Mr. White mentioned a case of recent occurrence, where, by a change of screw only, the speed of a ship was raised from 12 to 13¼ knots per hour.

M. Marchal, of the French Génie Maritime, contributed an interesting paper, in which the results of a number of experiments, made by order of the Government, were described. It was desired to obtain data for guidance in deciding on the relative advantages of two or three screws, as applied to an ironclad of 10,000 tons. A model steamer of 10 tons was built, and tried at "corresponding speeds," with two screws and with three. The publication of this paper marks a distinct change of policy in France, and it places before English designers a mass of valuable facts, which may prove very useful hereafter as the speeds of ships are increased.

Mr. Hall read a paper on "Flexible Shafting for Screw Steamers," describing a plan by which he hopes to reduce the number of breakages or serious accidents to the screw shafts of ocean-going steamers. His contention was that in not a few cases there is a want either of accuracy in the line of shafting and shaft-bearings, or of rigidity in the hulls of steamships; so that, by special joints between the various lengths of shafting, a certain amount of flexibility might advantageously be secured. Experience will prove whether he is correct or not in the anticipation that his plan will reduce accidents or breakages—serious matters in single-screw ships carrying large numbers of passengers and having very small sail power.

Another important group of papers are those dealing with the use of rolled and cast steel for shipbuilding. It is well known that steel is rapidly gaining upon iron, and Mr. Martell (of Lloyd's) stated some very interesting facts as to the extension of its employment in the mercantile marine. War-ships are now all steel-built. Seven years ago only 4,470 tons of steel ships were built, as against 518,000 tons of iron ships. In 1885 over 165,000 tons of steel ships were built, as against 290,000 tons of iron. Confidence in steel was expressed by Mr. Martell in his paper, echoed by Mr. Ward in another excellent paper recording eight years' experience in building steel ships, and indorsed by all who took part in the discussion. Incidentally the question arose of the introduction of steel made by the "basic" process for shipbuilding purposes; as yet this "make" of steel has not found much favor; but the Admiralty authorities are now about to undertake a series of experiments from which much may be learnt. Every one agrees that thorough and systematic testing has done much to secure the excellent qualities of steel now made by both the Bessemer and the Siemens processes; and even the manufacturers are in favor of maintaining the full severity of the tests in order to prevent any deterioration in quality. Of more recent date than the use of "mild-steel" plates and bars is the introduction of mild-steel castings in lieu of iron forgings. Mr. Warren, who had been chairman of a committee appointed by the Admiralty to look into this question, gave to the meeting an excellent summary of the results of their inquiries. There can be no question but that heavy iron forgings are doomed to give place to steel castings, which can be produced rapidly and cheaply, of sound and ductile quality, and in finished forms, avoiding costly machine work. As a record of experience up to date, Mr. Warren's paper will have a permanent value.

The remaining papers on the list are of a miscellaneous character, but all of considerable interest. Mr. Heck described a "Mechanical Method of Finding the Stability of a Vessel," by means of a simple model. This is a very ingenious and labor-saving device, likely to prove of great assistance in ordinary ship yards, where a staff of trained calculators may be wanting. Mr. Stromeyer described a "Strain Indicator" which he has invented.

This instrument is extremely simple in its construction; the essential parts consisting of two flat plates between which is inserted a "rolling pin" of fine steel wire. Relative motion of the two plates causes the rolling pin to rotate, and its rotation is the means of measuring the strain to which the material is subjected in any portion of a sample or a structure to which the indicator may be attached. If this instrument answers as well as it promises to do, much will be learnt from its indications as to the strains brought upon ships under various conditions, and more especially at sea. Such information carefully compiled and collated ought to prove of value in determining the structural arrangements of ships.

Admiral Paris, the venerable Curator of the Naval Museum at the Louvre, long known for his eminence as a scientific naval officer and as an archæologist in shipbuilding, attended the meetings, and contributed an interesting paper on the "Rolling of Ships," exhibiting an instrument designed to represent the relative movements of ships and waves. His reception was deservedly cordial.

Capt. Colomb described, in a well written paper, some of the more important results of recent measurements of turning powers of ships in the Royal Navy. These trials are now systematized, and much has been learnt from them which will be of value to future naval tactics, as well as useful to shipbuilders in designing rudders and steering appliances. A novel steering gear was described by Mr. Maginnis, who also laid before the Institution some valuable autographic information on the obscure subject of the strains brought upon a rudder when it is "put over" to various angles in a ship moving at speed.

Mr. Read's contribution, "On the Strength of Bulkheads" in ships, was seasonable, the recent loss of the Oregon having again drawn public attention to the necessity for water-tight subdivisions as a means of safety from foundering. Mr. Read put into a mathematical form the principles which should regulate the construction of bulkheads if they are to successfully withstand the water-pressure which must come upon them when the compartments are "bilged," and sea water enters. He did not deal with the principles which should govern the disposition of bulkheads; but these principles are well understood, and more generally acted upon now than formerly.

Another paper, by Mr. Benjamin, described a "Proposed Steam Lifeboat," which had been designed to be practically uncapsizable; and for that purpose, among others, made of a very peculiar form. The only other paper on the list described the improved methods of working anchors and cables devised by the author, Mr. Baxter. This was a paper of a practical and historical character, on a subject of undoubted importance.

From this hasty summary it will be seen that the Institution of Naval Architects maintained at its recent gatherings its old reputation for widely diversified topics of discussion. And it is to be added that the papers as a whole, numerous as they were, were also of more than average merit.—*Nature.*

THE JAPANESE IRONCLAD NANIWA.

H. I. M. SHIP Naniwa, which has recently left the Tyne for her destination, Japan, will be an important addition to the naval forces of that country. This vessel, together with her sister ship, the Takachiho, has been built by Sir W. G. Armstrong & Co., from the designs of their late naval architect, Mr. W. H. White, now Chief Constructor of the Navy.

The principal dimensions of the Naniwa are: Length, 320 ft.; breadth, 46 ft.; and draught, 18 ft. 6 in.; with a displacement of 3,650 tons. The vessels are constructed of steel throughout, and the combination of economy of material with due regard to strength is remarkable in both ships. Throughout the entire length, and covering the machinery, boilers, magazines, and steering gear, there is a strong protective deck about 3 in. thick, extending amidships from about 1 ft. above the water line to 4 ft. below. The hull is divided throughout into numerous water-tight compartments. The stem, which is ram-shaped, is formed of a solid steel forging, and is strongly supported by the protective deck. The openings in this deck are provided either with armor shutters or gratings, and coffer-dams are formed around such of the passages as must be kept open in action, to complete the protection. The ship is fitted with two military masts, mounting two Gatling guns behind shields in each top, but no sails are carried. We congratulate the Japanese in thus cutting themselves adrift from the obsolete tradition which still deforms and encumbers so many of our purely fighting ships with masts and yards.

The armament is placed on the upper deck, and is exceedingly powerful. At the bow and stern two 35 caliber 10 in. guns are mounted on revolving center-pivot carriages, giving an uninterrupted arc of fire of 240 degrees. The mountings, which were designed at Elswick, present many novel points, and have proved most satisfactory in practice. The training is effected by means of hydraulic engines placed directly under each gun beneath the protective deck, so as to be secure from injury. A shaft is led up to the deck, and engages by means of a pinion in a rack fixed to the base of the revolving carriage. There are two engines to a gun, each capable by itself of performing the rotation, a duplication of parts which greatly diminishes the risk of accident. The working platform, which is in rear of the gun, provides space for the crew, and contains the mechanism connected with the elevation and training; it revolves with the carriage, the crew being sheltered by a steel shield. The carriage is fitted with Vavasseur compressors, and the gun, after discharge, returns automatically into the position of firing. The elevation is easily performed by simple gearing, while the loading is carried out at a fixed station, placed amidships, and protected by stout steel armor, within which are situated the hydraulic rammer and hoists for the charges and projectiles.

Spaced along each broadside on projecting galleries are six 6 in. guns, also 35 calibers in length, with a horizontal range of 130 degrees, mounted on Vavasseur center-pivot automatic carriages, covered by steel shields, and along the upper works at every available space are placed a large number of Nordenfelt machine guns. On the ends of the bridge are situated two 6-pounder rapid-fire guns.

A conning tower of steel armor stands on the forward bridge, and within it are placed the engine-room telegraphs and various voice tubes, the hydraulic steering wheel, the directors for simultaneous electric firing of the guns, etc.

Four powerful arc lights are placed on elevated stations at either end of the forward and after bridges, capable of covering with their rays the entire space surrounding the ship. The engine-rooms, stokeholds, magazine and shell-rooms, and other compartments below the protective deck, are illuminated by incandescent electric lamps, as are also the coal bunkers on deck and the captain's state-rooms.

Immediately before and abaft the coal bunkers on the protective deck are situated four stations for discharging locomotive torpedoes on the broadsides; the discharge being operated either from the upper deck or down below. The steering gear is either hand or hydraulic, on the Elswick pattern, the steering wheels being placed both in the conning tower and in the wheel house beneath it. Both ships have been engined by the well-known firm of R. & W. Hawthorn, and much credit is due to that firm for the excellent design and arrangement of the engines. These are compound, horizontal, direct acting, driving separate screws; each set being placed in its own engine room. With the large experience now possessed by Messrs. Hawthorn in this class of engine, they have been able to secure

an exceptional lightness and compactness combined with the requisite strength. The engine rooms are unusually spacious and roomy, access being easily obtained to every part of the engines, a great advantage in the case of a vessel which may be expected to pass much of her time in hot climates. The starting and reversing gear of both engines is brought near together, an arrangement which greatly facilitates their efficient control on entering or leaving port, etc.; in fact, in case of need, both sets could be easily started or stopped by one man.

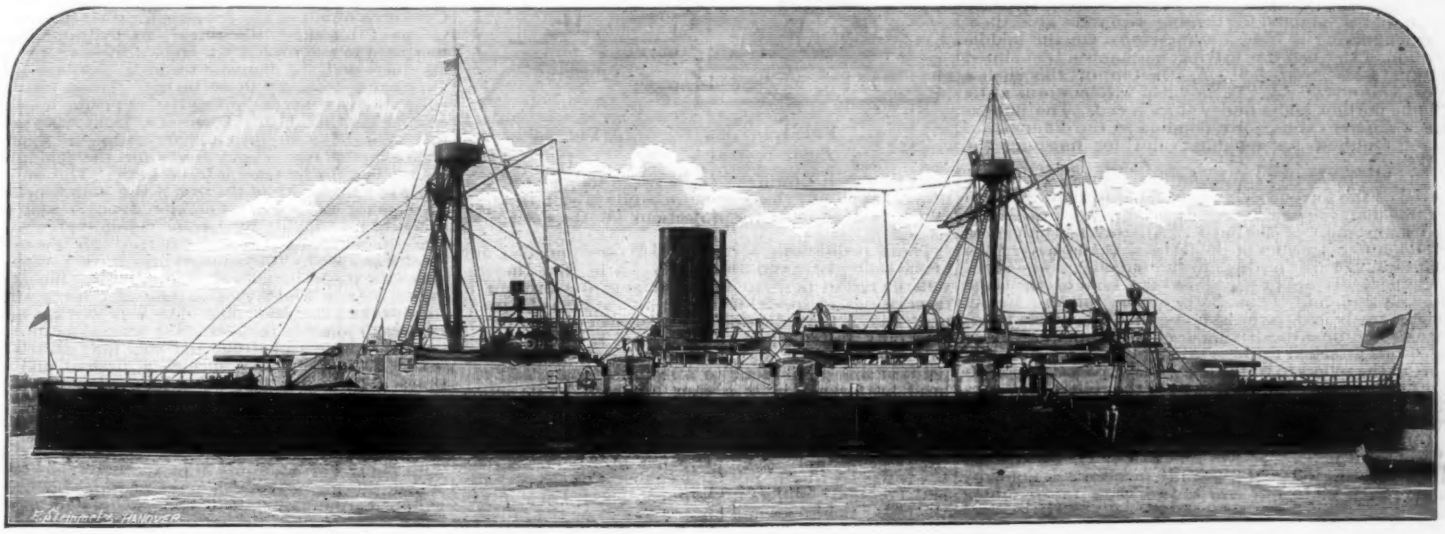
This admirable arrangement of the engine rooms is greatly enhanced in appearance by a liberal supply of electric incandescent lamps, which render the rooms as light as day, even with the fighting shutters closed. Steam is supplied by six steel boilers 19 ft. by 11 ft., with a collective heating surface of 15,600 square feet, and there is in addition an auxiliary boiler for the various capstan, winch, steering, and pumping requirements. The stokeholds are fitted to be worked in plenum, air being driven in by fans of sufficient power to maintain a pressure of air of not less than 2 in. of water. The total coal stowage is 800 tons, capable of driving the ship about 9,000 miles at a speed of 13 knots.

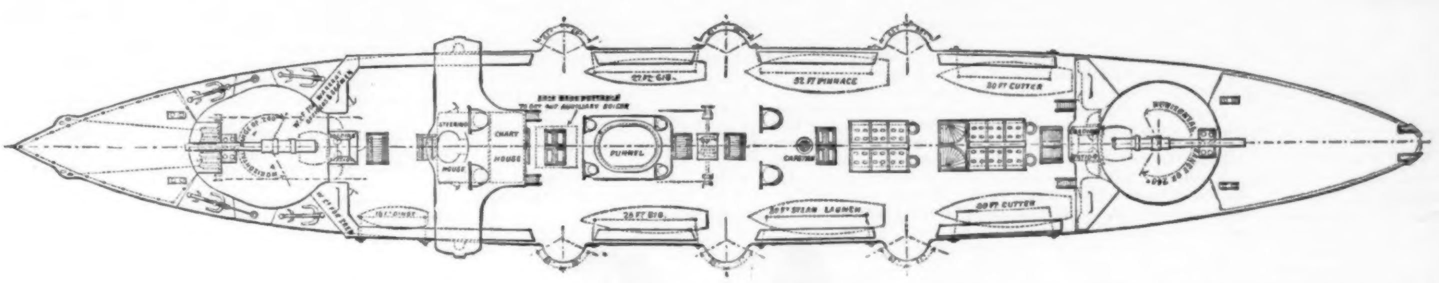
The spacious and admirable arrangements for the accommodation of the officers and crew, numbering together about 325, are very noteworthy. The fittings throughout are excellently contrived. The chief state rooms are amidships, and are particularly well lighted and ventilated. Forward on the main deck, space for the crew is provided, and throughout every detail which could contribute either to their necessities or comfort has been carefully anticipated and applied.

At the official trial of the Naniwa, a mean speed of 18·72 knots was obtained with 7,235 indicated horse power.

It will be seen from the above description that these vessels embody a high attainment of formidable offensive and defensive qualities, and reflect credit alike on their designer, the constructive capabilities of their builders, and the enterprise of the government which has become possessed of them.

It may be a matter of regret that vessels of this character, whose want is so urgently felt in our own fleet, should not be about to increase the numbers of our lamentably deficient cruisers, but we can sincerely congratulate the Japanese Government on the acquisition of these fine ships. It is certainly an indication of the immense development which has taken place in Japan of late years that she can now claim to be the possessor of the fastest and in some respects most formidable cruisers afloat, and we are sure that the officers of the Japanese Navy, are fully capable of appreciating their valuable properties and of making efficient use of them should an opportunity be presented.—*Engineering.*





THE JAPANESE IRONCLAD NANIWA.—CONSTRUCTED BY SIR W. G. ARMSTRONG, MITCHELL & CO., LIMITED, NEWCASTLE-ON-TYNE, FROM THE DESIGNS OF MR. W. H. WHITE.

A NEW DEVICE FOR SUBAQUEOUS FOUNDATIONS.*

IN carrying out the pneumatic foundations, an iron caisson of the form of the object required is generally used as a working chamber. The masonry carried up upon this is usually constructed within an iron sheathing, which serves to protect the new work from injury by friction as it is pressed down into the ground, and also acts as a coffer dam. The caisson and the sheathing remain permanently in the structure. Many attempts have been made to lessen the cost of this system, caused by the loss of the iron. Works have been carried out in which the caisson served only as a diving bell, and was afterward removed; but this method, apart from its great cost, only answers where the foundation does not go deep into the bottom, and then only for special cases.

In another direction saving of cost has been sought by removing the upper iron sheath after the masonry has been carried up sufficiently high, and using it again.

Already, in 1851, Pfannmüller had suggested, in a scheme for bridging the Rhine at Mayence, that the upper portion of the iron sheaths for the piers should be screwed off when the masonry was carried up above the water-level, and used again at another pier. In the case of the Saltash Bridge Mr. Brunel removed the iron cylinders, 37 ft. in diameter, for the whole depth of about 56 ft. in which the piers were not embedded in the bed of the estuary. In constructing the Antwerp quays, the contractors built the masonry, which was founded upon pneumatically sunk caissons, within massive iron sheathings, which, when the masonry was far enough advanced, were unbolted from the caissons, lifted bodily, and reused at another part of the wall. As the foundation of the masonry did not go far into the solid, the friction to be overcome in lifting these sheathings was not great.

In 1882, the Societa Italiana began the founding of a quay-wall, about 220 yards in length, along the corrected course of the Tiber, for the protection of the Villa Farnesina. The work was all done in the dry, the great curve of the Tiber not being cut out till later. The wall was founded upon a series of iron caissons, 67 ft. 7 in. long, 15 ft. 9 in. wide, and 29 ft. 6 in. deep. The masonry was brought up for 23 ft. in rough tufa and puzzuolana-mortar, and for the remaining 6 ft. with a facing of travertin blocks.

A sheathing of unusual construction, which was put up to its full height at once, was used, perhaps, rather as a protection during the sinking for the rough masonry in slow-setting mortar than as a coffer dam in which to build the upper masonry. This sheathing consisted of vertical iron plates 23·6 in. wide, connected together by two flat bars riveted together, between which the edge of the plates was pushed. There was no filling or calking of the joints, and no attachment to the caisson. When a length of walling was finished, the plates and bars were pulled out and used again in another length.

Inspired by these works, the author designed a "foundation mantle," which easily takes to pieces, and is adaptable to any form of caisson. It consists of vertical plates 0·2 in. thick and 2 ft. 7 in. wide, in 6 ft. 7 in. lengths, joined together at the horizontal points by double coverplates and a double row of bolts. Laterally these plates are kept in position by fitting in a riveted I formed of two bars, 5·9 in. by 0·47 in. separated by a bar 2 in. by 0·27 in., all three being riveted together. The vertical plates are not fastened to these I irons, but the joint is calked. The Is break joint with the plates, and are only lightly attached to the caisson.

In the winter of 1883-84 the two abutments and two piers of the bridge over the Wisloca at Dembica, in Galicia, were erected upon this plan. The area of the foundation of the abutments is 68 square yards each, and of the piers 57 square yards. The foundations varied in depth from 20 ft. to 26 ft. below low water, and from 28 ft. to 37 ft. below the ground level, and four or five rows of the movable plates were used according to circumstances. The materials sunk through were sand gravel first, and, lower, stiff clay. When the foundation of one pier was completed and the masonry brought up high enough, the sheath was removed to the next pier. It was used four times.

To obviate any danger of boltheads, or, rather, projecting pieces, catching on the masonry as it is being drawn out, the space between the sheath and the machinery is filled with sand as the latter progresses. The sheath is removed by windlasses, which draw out the vertical plates and fish-joints one by one. The joint between the sheath and the caisson is simply broken in this operation.

The weight of the sheath, including all joints and fastenings, is, for the lowest row of plates, 19 lb. per square foot, and for the rest 15·6 lb. If the plates have to be reused over a caisson of different shape from the one from which they are being taken, it may be necessary to bend them to the required curve, and to this end they must be of the best material. The vertical fish-joints are the same for all shapes of caisson.

It had been intended to make careful tests to ascertain the amount of friction encountered in drawing off the sheath, but the floods of June, 1884, made it necessary to get the work done as soon as possible, and the tests were, therefore, confined to the right pier, which was 115 ft. from the bank, and founded 21·6 ft. below low water, and 38 ft. below the surface of the ground, made up of sand and clay 10·50 ft., loose stones and sand, 18·60 ft., and firm clay 8·90 ft.

While the sinking of one of the caissons was in progress, the giving way of the joints of two of the vertical plates, at their joining with the caisson, gave the opportunity of calculating the external friction, the bottom of the caisson being at the time 5·2 ft. below low water, and 23·3 ft. below the surface of the ground. This gave a resistance due to friction of 5·1 tons per foot run of circumference, equivalent to 492 lb. per square foot of surface of the sheathing.

These and some observations of other plates which gave way on the further sinking of the caisson, taking into account the degree in which they followed the caisson or stayed behind, showed that the earth pressure on the inside of the sheathing is proportional to the friction, just as is the case on the outside.

These slight observations showed that the coefficient of friction inside is at least as great, if not greater, than that outside, and that, therefore, passive earth pressure produces as great an amount of friction as active earth pressure. It was now of interest to determine the resistance to friction when both surfaces of the sheathing were sliding, as is the case when the sheathing is drawn off, instead of only one, as in the former cases; and whether, as must be theoretically assumed, the resistances work simultaneously on both sides of the plate, and are thus proportional to the sum of the inner and outer coefficients of friction. If this is so, a comparison of the theoretical calculated outside friction with the observed resistance to the drawing up of the sheathing should show the former to be at most one-half the latter.

The calculations have been made for all the cases in which the plates were above water (there being no theory giving useful results for material permeated by water).

The theoretical earth pressure was determined by Rebhann's Construction, in which the weight of the material was taken at 98·3 lb. per cubic foot, and the angle of repose for sand with loam at 38°, and gravel and sand 36°. After a long series of observations, the coefficient of friction for the outside was found to be 0·466, and for the inside 0·588, or twenty per cent. greater than the outside friction. The results of the calculations were reduced to diagrams which thoroughly proved that, with the simultaneous action of two surfaces of the same body (as in the case of the sheathing when being drawn off), the resistances to friction act simultaneously on the two surfaces, and, therefore, must be added together.

The accompanying table refers to the land pier on

* By E. Gaertner. Translated for Abstracts of Institution of Civil Engineers.

a.	b.	c.	d.
Depth below Surface of Ground in Meters.	Mean Resistance to the Winding up of the Vertical Plates of the Sheathing.		
	Per Plate 2 Feet 7 Inches Wide.	Per 1 Meter of Circumference of Sheathing.	Per Square Meter of Sheathing.
	Tonnes.	Tonnes.	Kilogrammes.
1·0 (3·28 ft.)	0·140 (0·138 ton)	0·177 (0·053 tons per ft.)	177 (36·3 lb. per sq. ft.)
2·0	0·560	0·709	354
3·0	1·390	1·759	586
4·0	2·620	3·316	829
5·0	4·560	5 772	1,154
6·0	5·550	7·025	1,171
6·5	6·290	7·962	1,224
6·75	7·290	9·227	1,367
7·10	9·150	11·582	1,631
7·50 (24·6 ft.)	11·310 (11·13 tons)	14·316 (4·295 tons per ft.)	1,908 (391·1 lb. per sq. ft.)

the right bank of the Wisloca. From this table it is seen that the friction at considerable depths, and especially where the earth is saturated with water, increases very rapidly. The mean water level in the case of the pier to which the table refers was about 4·7 meters (15·4 ft.) below the surface of the ground.

ROLL TURNING LATHE.

WE illustrate below a double lathe for turning chilled cast-iron rolls, such as are used in roller mills. This lathe, which is one made by the Werkzeug und Maschinenfabrik Oerlikon, near Zurich, is very strongly built, and is adapted for turning two rolls at a time. Our engraving is from *Engineering*. On the middle portion of the bed the driving mechanism is mounted within a cast iron shell. At the top of this shell a short transverse shaft is provided with a worm at its middle portion and a pulley at each end. The pulleys are of different sizes, corresponding to the difference of speed required for roughing and for finishing the rollers.

The worm engages a horizontal worm wheel, which is keyed to the top end of an upright shaft, and a worm on this shaft imparts motion to a large worm wheel on the main shaft of the lathe. All this mechanism is common to both sides of the lathe. At the ends of the main shaft, which projects to the outside of the shell, suitable heads are provided to take hold of the lathe dogs on the ends of the shafts of the rollers. Heavy tables are bolted to the bed on either side of the headstock containing the driving mechanism, and two extra pedestals attached to these tables give a powerful support to the rollers to be turned. These pedestals can be shifted according to the length of the rollers, and contain sleeves corresponding with the diameters of the roller shafts.

On both sides of the roller carriages are fitted to slide bars which are cast to the tables. These carriages are self-acting lengthwise, while facework is done by hand; each slide rest carries two tools for roughing and one for finishing. If it be desired to slide the tool by hand, a screw nut, which tightens the pinion at the end of the screw spindle of the carriage, is loosened, and the pinion then revolves idly. The self-acting carriages derive their motion by a train of gear wheels from the toothed surface of the heads of the main shaft.

These lathes are constructed in different sizes; the one shown will take rollers of 24 in. in diameter and 40 in. in length, and weighs about 6 tons.

THE HYDRA-HEADED RAIL.

THIS system of permanent way, which we here illustrate, is the joint invention of Messrs. Cowdery & Thomas, of the New South Wales Government Railway, Sydney. The object which the inventors have kept in view has been to design a permanent way distinguished by great smoothness and fewness of working parts. Each rail is built up of two similar sections, A A, Fig. 1, having approximately the shape of the letter Z. As the two sections are identical in every respect, each of the four flat surfaces can in turn be placed uppermost to take the wear. The chair, B, is made from a strip of plate 4½ in. broad,

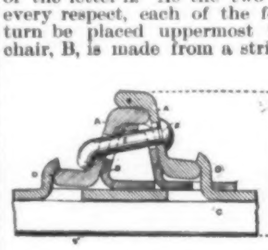


FIG. 1.

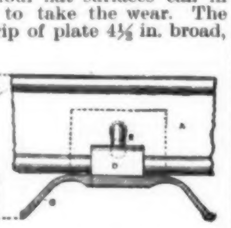


FIG. 2.

bent into such a form as to fit between the two sections of the rail, and having at one side a slot through which one of the two projections on the sleeper, C, passes.

These projections, or snugs, D D, are punched out of the solid plate, and are of such a form that they retain the rail in position sideways, and also prevent it from rising. A special feature in this system of permanent way is the reduction in the number of loose parts. The only fastening is the lock-pin, E, which passes through the chair and both sections of the rail; the point of this pin is bent to an obtuse angle, and the head has formed on it a cam, F, which, by its action when turned with a spanner, tightens the grip on the rail. The lock-pin is inserted with the angled part pointing upward, and half a turn brings it into the position shown in the illustration, in which it firmly binds together both rails and chair. The sleepers are laid 3 ft. apart, and an extra one is inserted at joints of the rails; the upper and lower sections of the rails are made to break joint. It is expected that the breaking of the joint will secure great smoothness and freedom from knock. Two miles of line on this system have been laid between Blacktown and Paramatta, New South Wales, under the supervision of the inventors, and, from reports which have come to hand from Sydney of the trials made over this portion of the line, the new rail bids fair to engage the attention of railway companies. In laying this rail, fish plates, screw bolts and nuts, and wooden keys are dispensed with; and being laid on steel sleepers, it is claimed that much less expenditure will be required in maintenance than with the ordinary rail.

A short section of this rail is laid in the New South Wales Court at the Indian and Colonial Exhibition, South Kensington.—*Mech. World.*

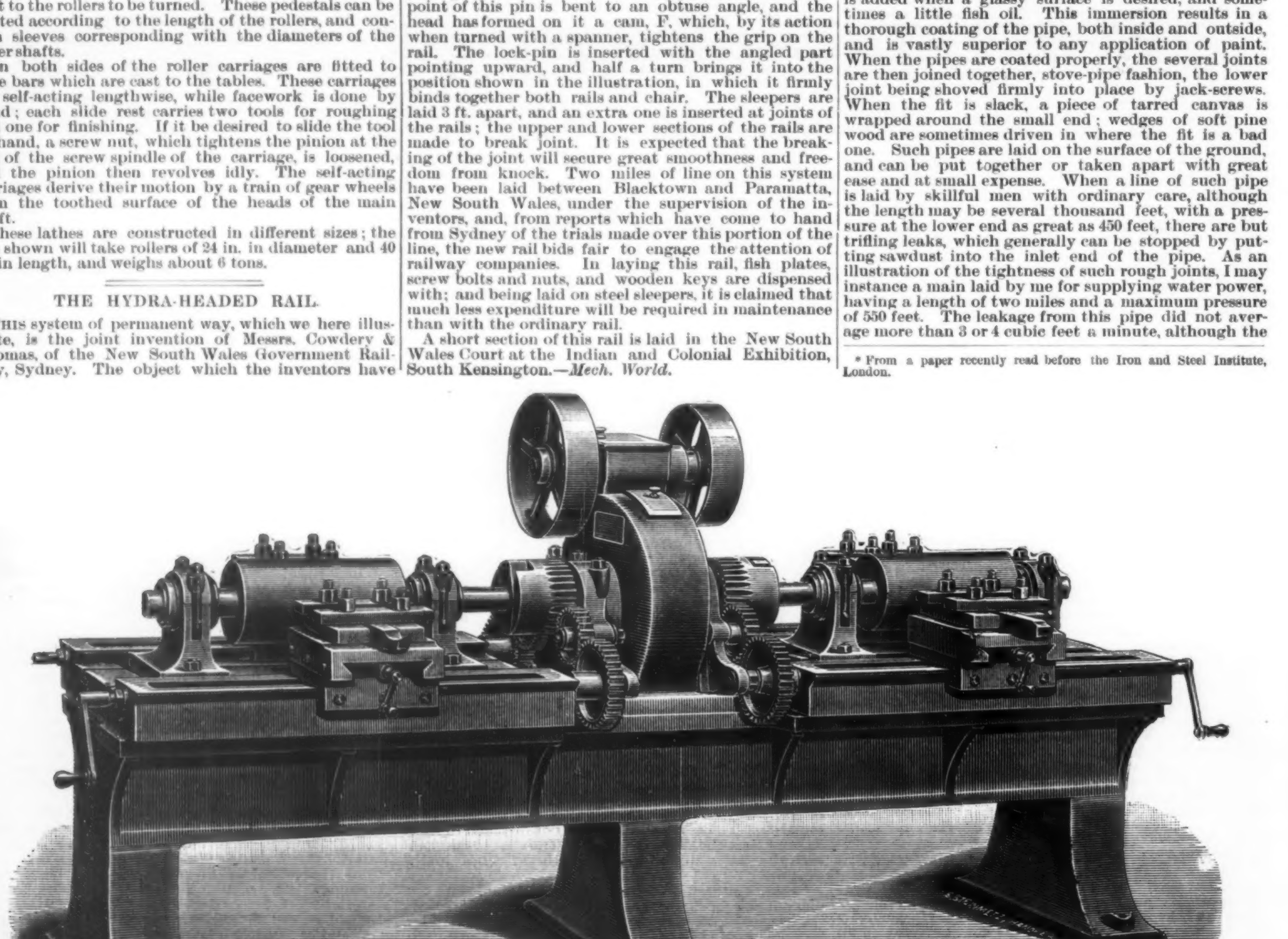
WROUGHT-IRON WATER PIPES.*

By HAMILTON SMITH.

WROUGHT-IRON pipes are largely in use in the Pacific States and Territories of the United States as water conduits; cast-iron pipes are only used for city distributing mains, where frequent connections with service pipes are required. The adaptation of wrought iron for this purpose was due to the following causes, and affords an apt illustration of the old proverb that necessity is the mother of invention. The method of hydraulic mining was introduced or invented in California in 1852. It may roughly be defined as the discharge of jets of water, actuated by gravity with a considerable head, against a bank of auriferous gravel, the water acting first as an excavator and afterward as a carrier of the washed material. The supply of water for these jets at first was conducted through hose made of heavy cotton duck cloth, which was strengthened by outer nettings of cordage when the pressure was large. This hose was costly and short-lived. It was not practicable to use pipes made of cast iron; first, on account of the prohibitive cost of transportation over steep mountain roads and paths to the mines, and, second, because heavy cast-iron pipes could not be cheaply and quickly moved from place to place in the mine, the exigencies of such mining requiring frequent changes in the position of the supply pipes.

In 1853 an ingenious miner laid in his mine a line of pipe consisting of joints of ordinary stove pipe, made of very thin sheet iron, lightly fastened together with cold rivets, with the joints united stove-pipe fashion, *i. e.*, the end of one joint tightly shoved into the larger end of the succeeding joint, with the smaller end pointing down stream. This experimental pipe was some 5 or 6 inches in diameter. The pipe answered the desired purpose admirably, and in a comparatively short time all the many hydraulic gravel mines in California obtained the pressure for their water jets by means of thin sheet-iron pipes. As hydraulic mining increased in magnitude, the sizes of these supply pipes also increased, the diameter for main lines for a large mine being from 22 to 30 inches. These pipes, as a rule, are made at the mine, the requisite machinery costing less than £100. The iron is from 0·065 to 0·134 inch (Nos. 16 to 10 Birmingham gauge) in thickness, with a double row of cold rivets for the longitudinal seam when the pressure is to be large. The only test made of the quality of the iron is the judgment of the pipe-maker, who can generally discover and reject sheets of bad quality by defects manifested when the plates pass through the rolls; in fact, this is one of the chief reasons why the mine-owners have preferred to make the pipes themselves. The length of the separate joints is from 18 to 25 feet, one end being slightly smaller than the other end. As a protection against rust, each joint is immersed for several minutes in a bath of boiling asphaltum and coal tar; a little resin is added when a glassy surface is desired, and sometimes a little fish oil. This immersion results in a thorough coating of the pipe, both inside and outside, and is vastly superior to any application of paint. When the pipes are coated properly, the several joints are then joined together, stove-pipe fashion, the lower joint being shoved firmly into place by jack-screws. When the fit is slack, a piece of tarred canvas is wrapped around the small end; wedges of soft pine wood are sometimes driven in where the fit is a bad one. Such pipes are laid on the surface of the ground, and can be put together or taken apart with great ease and at small expense. When a line of such pipe is laid by skillful men with ordinary care, although the length may be several thousand feet, with a pressure at the lower end as great as 450 feet, there are but trifling leaks, which generally can be stopped by putting sawdust into the inlet end of the pipe. As an illustration of the tightness of such rough joints, I may instance a main laid by me for supplying water power, having a length of two miles and a maximum pressure of 550 feet. The leakage from this pipe did not average more than 3 or 4 cubic feet a minute, although the

* From a paper recently read before the Iron and Steel Institute, London.



IMPROVED LATHE FOR TURNING CHILLED ROLLS.

only protection from changes of temperature was a couple of boards tacked together and placed over the pipe.*

After successful practice in the mines had demonstrated the advantages and capabilities of wrought-iron pipes, they were used for permanent conduits both for conducting water to mining districts across deep mountain gorges and also for the supply of cities. San Francisco, a place of some 300,000 inhabitants, receives its water through two lines of such pipes, and a third pipe, many miles in length and of large diameter, is now being laid for an additional supply. For permanent conduits, the joints of a pipe of considerable diameter are generally riveted together; for small diameters with high pressures, lead joints are used. Such conduits are, of course, placed in trenches and covered with earth, in order to avoid excessive alternations in contraction and expansion; slip-joints need not be used, as the pipes are sufficiently elastic to permit changes in length due to variation of the temperature of the water. The following statement will illustrate the Pacific coast practice with conduit pipes, the flow in all cases being caused by gravity:

Name.	When laid.	Lgth.	Diameter.	Maximum Pressure.	Maximum Tensile Strain on Iron.	Description of Pipe.
		Feet.	Inches.	Vertical Feet of Water.	Lb. per Square Inch.	
Cherokee	1870	12,798	30	887	17,549	Plate iron, double riveted.
Virginia City	1872	37,100	11	1,720	about 15,000	Plate iron, double riveted.
	1873	37,100	10	1,720	(?)	Lap-welded tubing; outer screw couplings.
Texas Creek	1878	4,439	17	700	about 18,000	Plate iron, double riveted.
Humbug	1868	1,194	26	120(?)	11,500	Single riveted iron $\frac{1}{16}$ inch in thickness; two pipes each 26 inches diameter, laid side by side.

The two Virginia City pipes are laid side by side. The lead joints for the riveted pipe under the enormous pressure of 1,700 feet at first gave considerable trouble; the lap-welded pipe gave no trouble whatever. The general tensile strain on the Texas Creek pipe is about 16,500 lb. per square inch. The oldest of these pipes—the two across Humbug Canon—are notable for having been laid seventeen years ago of iron single-riveted only $\frac{1}{16}$ inch in thickness; when I last heard from them, a few months ago, they were reported to be in good order. The other pipes are also stated to be now in excellent condition. The iron for the Virginia City and Texas Creek riveted pipes was of very inferior quality; the iron for the Cherokee pipe was of ordinary quality; yet it will be observed these pipes have for many years past been subjected to tensile strains which must seem almost fabulous to one only accustomed to cast-iron water pipes. So far as rust is concerned, in my extensive experience I have only seen one notable instance where an asphaltum coating properly applied did not protect the iron, and that was with a pipe over which passed a stream of water highly charged with sulphate of iron. I may also remark that when iron has once been attacked with salt rust from sea water, it seems to be very difficult to prevent further rust. The California experience with double riveted pipe, made of a superior article of plate iron, can thus be summed up:

Such pipes can be with entire safety subjected to a constant maximum tensile strain of 16,000 lb. per square inch. For a period of twenty years an asphaltum coating has prevented rust, and also the formation of interior tubercles where soft water flows through the pipe. Lap-welded iron tubes of sizes up to 15 inches in diameter are now largely used in the United States for conduit pipes, and will safely stand a strain of about 20,000 lb. per square inch. They are almost exclusively used in the Western mines for pump columns, owing to their combined lightness and strength. The lines of pipe through which petroleum is pumped from the Pennsylvania oil-wells to the seaboard are made of this tubing, the diameter generally being six inches.

The query presents itself, Why should not wrought iron or, still better, steel be used for conduit pipes in preference to cast iron? If it answers the desired purpose in California, why should it not do so in other parts of the world? To one like myself, who has for years been accustomed to the California practice, it seems as irrational to build a pipe carrying water under considerable pressure of cast iron as it would be to build a suspension bridge with the supporting chains made of cast iron. Experience in the United States has shown that the practicable limit of size for cast iron mains is a diameter of about 4 feet, even when the pressure is less than 100 feet. It is evident that a pipe of wrought iron or mild steel can be safely made of almost any desired size, and this may be of much advantage if it be desired to conduct a large supply of water through pipes for city or other use. For instance, with an inclination of 3 feet per mile, a single pipe 8¼ feet in diameter will carry 280 cubic feet per second, while seven pipes each 4 feet in diameter would be required to transport the same quantity of water with the same inclination. The cost of the large pipe made of steel or wrought iron would be considerably less than one-half the cost of the seven small pipes made of cast iron. The ideal conduit for high pressures is a welded steel tube; such tubes could probably be subjected to a tensile strain of 25,000 lb. with perfect safety, and would be much preferable to riveted pipe, not only on account of superior strength, but also by reason of almost perfect interior smoothness. It seems to me that this question is well worthy of the attention of British steelmakers and hydraulic engineers. The adaptation of a superior and cheap metal such as mild steel for conduits will permit the construction of hydraulic works in many parts of the world which now appear to be impracticable, owing to the cost of many of the methods still in use for the transportation of water.

Mr. J. Riley said that about twelve years ago Mr. Russell Aitken proposed to the municipality of Bombay a very extensive scheme to bring water a considerable number of miles to the city, and to make the main of steel. It was looked upon as rather a mad scheme by a good many people, and consequently it hung fire. Only in the present year had the municipality decided to extend its waterworks, and it had gone in for a cast-iron main, the order for which was taken by a Glasgow firm. A few years ago his firm were visited by some gentlemen from New York, who had a scheme for a main to increase the supply of water to New York city. It was intended that the main should ultimately be 80 miles long. He went carefully into the matter with them, prepared estimates as to the cost, and made all arrangements for supplying the main if the scheme was completed. About 30,000 tons of steel would have been required for it, but the scheme had not yet come to fruition. Under the guidance of one of the American gentlemen, he made 100 tons of pipe 13 inches in diameter and $\frac{1}{16}$ inch thick, which was sent out to the Central States of America. There was subsequently some talk of a large main for New South Wales, and he proposed to the engineer that it should be of steel, and said he would undertake to supply it, ship it, and deliver it in New South Wales at a considerably lower cost than it could be obtained of cast iron. He believed that eventually a portion of that main was constructed of wrought iron, but he did not know if it was finished yet. Following that came the Bombay scheme, which he tried to turn in the direction of steel, but failed. Last of all, he worked constantly on the largest scheme that had been heard of in this country, namely, the scheme for the supply of water to Manchester from Thirlmere. He submitted to the engineer of that scheme a proposal to make the main of steel; but the suggestion was not carried out, because they wanted experience of how the plates would stand in the matter of corrosion. If he could have pointed to any experience to remove the doubt on that point, or if the engineer would have taken the responsibility, he believed they would have had an example in this country of the largest steel main ever constructed.

Mr. E. A. Cowper said perhaps it would be interesting for him to mention that the Kimberley waterworks had a 14 inch main, only ¼ inch thick, and 18 miles long, and it had been most satisfactory.

* The extreme range of temperature was from 10° to 107° Fahr. in the shade.

PROF. JOSEPH HENRY AND THE MAGNETIC TELEGRAPH.*

By EDWARD N. DICKERSON, LL.D.

Mr. President and Gentlemen, Trustees of the College of New Jersey:

The pleasing but sad duty has been assigned to me of presenting to you this memorial tablet of the beloved master who once shed the luster of his genius over this ancient seat of learning, and once attracted to its classic shades, allured by his great reputation, pilgrims from all lands, to drink from the living font of knowledge, ever replenished and refreshed by his ceaseless contributions.

I commit this monument to your tender care. May it ever remain enshrined in this beautiful temple! May its presence encourage those, and the successors of those, to whom he delivered his torch of science, ablaze with a light which had penetrated to the farthest ends of the earth, to tend that sacred flame; so that when they shall transmit it to their successors it shall still be borne high aloft in the upper atmosphere of pure truth with still increasing luster—a guiding beacon to the wayfarer, wandering and astray in the gloomy valley of ignorance, those deep defiles where the shadows seem ever darkening by contrast with the brightening mountain tops illumined by the rising sun of knowledge.

May it inspire the ingenuous youth who in the thronging years of the future shall gather about these altars, to search the character and achievements of the grand master, that they may be taught by him how to study, how to think, how to work, how to live, and how to die.

May it continue to remind those who annually are attracted here to witness the evidences of the growth of knowledge, as they are exhibited in the commencement seasons, that once this college was honored by the ministrations of Joseph Henry, an American, who, with means created almost wholly by himself, rivaled the achievements of the greatest scientists of the Old World, working with the resources of nobly endowed institutions and encouraged by the bounty of kings, and for years was ever a leader in the vigorous attack upon the arcana of nature, made by the champions of science in the early years of this century.

For those of us who enjoyed the happiness of knowing him well, and loving him dearly, no sculptured marble is needed to stir our hearts, or keep fresh in our memories that noble presence, which at once charmed and satisfied our senses. Nor, if the chisel of the artist were guided by the genius that once inspired Phidias, would it be capable of fixing upon dull, cold marble more than one of the almost infinite variety of expressions revealing to the world without the exalted being within.

But to those who have never seen him, or, having seen him, have never known him, and to those who shall come after us, it will be something to look upon this marble, and, inspired by the thoughts he uttered, and the deeds he did, contemplate its calm expression, and imagine what must have been the living man.

In the year 1839, nearly half a century ago, brought here as a student, I first saw Professor Henry. I remember it well—the time, the place, and the surroundings.

Boyish imagination had pictured the great discoverer as a venerable man, bowed down with the toil of years, bearing the furrows with which overtasked Nature revenges herself, traced upon his brow: such a person, perhaps, the artist has presented to us in the familiar picture of Humboldt in his library.

* A Memorial Address, presenting to Princeton College a tablet designed to commemorate the contributions to the electric telegraph of Joseph Henry.

How different the reality! In the maturity of a perfect manhood he stood:

"A combination, and a form indeed,
Where every god did seem to set his seat,
To give the world assurance of a man."

His clear and delicate complexion, flushed with perfect health, bloomed with hues that maidenhood might envy. Upon his splendid front, neither time, nor corroding care, nor blear-eyed envy had written a wrinkle or left a cloud; it was fair and pure as monumental alabaster. His erect and noble form, firmly and gracefully poised, would have afforded to an artist an ideal model for an Apollo. The joy of conflict and of triumph beamed from his countenance—a conflict in which, for years, he had struggled with the phantoms that guard the hidden treasures of nature, and had ever been victorious. And above all, surmounting all, infinite charity and gentleness—like the charity and gentleness of a loving mother for her erring children.

To him the youthful student bowed down in profound admiration. To him, and to his memory, for nearly fifty years, he has clung with ever-increasing love and affection. And now that seven years have passed away since death severed the bond strengthened by a lifetime of intimacy, he recurs with fondest memories to the many happy occasions when it was his good fortune to spend hours in sweet and instructive converse with this gifted mortal, to whom the whole book of nature was an open volume, out of which he ever read lessons of wisdom, and beauty, and truth.

As Professor Henry appeared in 1839, so he continued till 1847, with but little change in the physical man—only that change which, like the changes in the early autumn, lightly touched with tints of exquisite beauty the mature growth of springtime and summer; and then with extreme reluctance, he departed from Princeton, called by his country to lay down the arms with which, as a soldier in the ranks, he had been waging his warfare against ignorance, and take command of the intellectual forces to be summoned and organized by him in the same glorious cause.

Born in the dying moments of the eighteenth century, his age was marked by the numbers denoting the years of the nineteenth. Like the century, with whose growth his growth kept pace, he had developed with almost unexampled rapidity; and at the age of thirty-two, when he took his chair here, although "he was but a youth, and ruddy, and of a fair countenance," and was armed only with a simple sling of his own construction, and pebbles from the brook of nature, he was equal to the trained warriors of maturer growth and superior armor, waging war against the Goliath that guarded the unexplored regions of nature's secrets; and like the great King of Israel, after the brunt of the battle was over, he came to be leader of the hosts, who once had been tending only a "few sheep in the wilderness."

Let us contemplate for a moment the intellectual stature of our departed teacher, considered merely as an investigator of natural laws, and measured by the standard established by the intellectual world.

It is in the order of nature that the intermittent progress of humanity is made under the guidance of gifted men, appearing from time to time, who push forward the outposts of truth, whether in morals or physics, calling upon their fellow-men to hasten and occupy the newly conquered fields. The names of such men are few, and are written upon the rolls of fame. Their glory belongs to no nation, but to all mankind. Sometimes simultaneously and in different parts of the world two such appear, who seem to have been cast in similar moulds, lest perchance one might die or fail, and progress stand still. Such men are Henry and Faraday, whose intellects were moulded with the same capacities, and who worked out their tasks in the same spirit. If either one had died before his work was done, the other was capable of doing it; and, in fact, both, in many cases, struck out the truth, each unconscious that the twin thought had been born in the brain of the other.

To those devoted friends and admirers of Faraday who delight in singing his well earned praises, and who best comprehend his achievements, it seems that his discovery that electricity might be produced from magnetism was his grandest result. Upon it depends many of the most important applications of electricity to the uses of man; and in the near future many more are coming. Tyndall, the successor of Faraday, does not restrain his enthusiasm when he contemplates this achievement. "I cannot help thinking," says he, "while I dwell upon them, that this discovery of magneto-electricity is the greatest experimental result ever obtained by an investigator. It is the Mont Blanc of Faraday's own achievements. He always worked at great elevations, but higher than this he never subsequently attained."

Let us accept the standard, and apply it to Henry; let the achievement measure the power of the man.

In November, 1831, Faraday read before the Royal Society his memorable paper "On the Evolution of Electricity from Magnetism," illustrated by drawings of the apparatus, in which Fig. 1 is the compound "spool," discovered by Henry in 1828, and which Faraday used in making his discovery. No publication referring to this paper had reached this country till April, 1832, when a vague reference, made to it in the *Annals of Philosophy*, was seen by Henry, which led to his publication of July, in *Silliman's Journal*, where he gave a full account of his great discovery, made by himself before he heard of Faraday's work, which, when compared with Faraday's paper of November, exhibits Faraday's experiment for solving the problem. When he wrote his paper, Henry, misled by the imperfect statement in the *Annals of Philosophy*, supposed that his experiment had differed from Faraday's, but was undeceived when the full publication reached him. In 1831, a teacher in the Albany Academy was very remote from London and the Royal Society.

In that same year, and in the same few weeks, Faraday first, and Henry after him, independently made the discovery of magneto-electricity—"the greatest experimental result ever obtained by an investigator," in the opinion of Tyndall.

In the same field, and during the same years, were the other great scientists of the world studying the same subject: Ampere, Arago, Oersted, Davy, and a host of others; but these two did it, and not the others, and Henry did it by devices of his own invention, unaided by anything which Faraday had discovered or

produced, while Faraday used Henry's electro-magnet in performing his most important experiment.

The towering heights which were scaled by the daring spirit of Faraday from the East were at the same time surmounted from the West by our own countryman. Both were climbing from opposite sides at the same time, and neither was conscious of the other's efforts till both stood, face to face, upon the summit. Had Henry been furnished with the corps of trained mountain guides and alpenstocks such as attended Faraday in his ascent, perhaps his foot would have first trodden the peak, and Prof. Tyndall's song of triumph have been addressed to him.

But when we compare Henry with Faraday! who is the acknowledged unit of comparison, the accidental conditions under which both existed and worked must be known, or justice cannot be done. Electrical science was the field to which both spontaneously directed their studies. Its mysteries at once excited curiosity, and baffled research. Its most obvious phenomena had only for a short time been recognized, and everything was to be learned. What they did in that science not only constitutes the greater part of their claims to reputation as investigators, but is almost the whole of our present knowledge of magneto-electricity.

But how superior in every respect, except in God-given intellect, was the equipment of Faraday! He was eight years older than his rival. In the year 1813 he was appointed "assistant" in the laboratory of the Royal Institution, under Sir Humphry Davy, then one of the foremost scientists of the world, who, attracted by Faraday's genius, was directing his studies and forming his mind. At that time Henry was but thirteen years old.

In the next twelve years Faraday was at work, with all the resources of the Royal Institution, under the instruction of the great Davy, in acquiring the knowledge with which he was armed when he began his original investigations; while Henry during that same period was struggling unaided for such education as might be obtained from the scanty resources of a country town, and with that proud independence ever so marked a feature of his character was supporting himself by teaching to others a part of that which he was learning himself.

In 1825 Faraday had so improved his great opportunities that, at the age of thirty-four, he was appointed "director of the laboratory" of the Royal Institution, where everything that science could suggest and money procure was at his command in aid of research. Henry was then a private tutor in a distinguished family at Albany, studying mathematics in hours when his duties to his pupils had ceased, and when other young men might have thought they had earned the right to relaxation and enjoyment.

In 1824, before Henry ever had in his hands any instruments for research in electricity, Faraday, thus trained and equipped, began his attack upon the problem of magneto-electricity, and failed; and in 1830 it was not yet solved.

The discoveries of deductive science need no apparatus. They are made and matured in the brain, and to record them is the only physical incident to their existence or development. Plato would have looked with disgust and contempt upon a laboratory, and would have scorned the suggestion that time, or place, or physical surroundings could affect the workings of his mind, or influence his deductions. But the new philosophy, which has changed the face of the world, is of no such ethereal nature. It is born in observation of physical things; it is nurtured upon experiments that cost money, and time, and labor; its maturity is in perfected arts, and in things to be seen, and handled, and enjoyed by the senses; its end is to subordinate the blind forces of nature to the uses of man—to mitigate the ills and multiply the joys of life. They who are the servants of this philosophy must be provided with materials with which to reproduce, in miniature, the conditions that exist in nature in grander proportions, or they cannot ask the questions whose answers they are seeking; and, other things being equal, he who is well provided with all these needful things has an immense advantage over another who lacks them.

For thirteen years Faraday had been pursuing his investigations, amply supplied, and was in the full career of successful experiment when, in 1826, his great rival first looked upon the course over which he was to run; and even then Henry had to depend upon the meager facilities of the Albany Academy and the voluntary assistance of an appreciative physician, Dr. Philip Ten Eyck, of Albany—a name to be held in grateful remembrance by all who feel a pride in the achievements of the great scientist, whose early efforts were assisted, and whose hopes encouraged, by this enlightened friend.

With such a beginning as this, who could expect that the young aspirant for fame should ever overtake his great leader in the friendly contest? And when he did overtake him, and in some important investigations surpass him, who shall deny that Henry, as a physical investigator, was the equal of him above whom it is conceded no other man has risen in this century?

In still further pursuing his researches into the subtle phenomena of electricity, Henry made, here in Princeton, another capital discovery, this time in advance of Faraday, which forms an important element in the science of electricity. It is to be found detailed in any schoolbook, under the name of "Henry's coils." His wonderfully elaborate investigations will be remembered by the students of that day, as they were conducted in part in the open air. Wires stretched across the campus, in front and in rear of Nassau Hall, were the means by which the questioner was cross-examining nature, and wresting from her reluctant grasp her hidden secrets. At that time telegraph wires did not exist, and those fine lines traced across the sky excited the liveliest interest in the students, whose fantastic guesses as to their significance were the cause of much pleasantry in the idle hours.

In the course of these investigations it was also the good fortune of our scientist to first discover the very curious phenomenon of "self-induction," as it is now called, which plays so important a part in the creation and use of electric currents on wires, sometimes injuriously and sometimes beneficially. Without the knowledge of its laws no duplex or quadruplex telegraph could be practically operated; with that knowledge it can be neutralized when it is injurious, and made available when useful. The brilliant spark which follows the pulling of the pendant attached to an electric lighter for inflaming a gas jet, now in common use, is one of the valuable practical applications of this principle so discovered.

In contemplating the discoveries of the scientist, there are two aspects in which they present themselves. In one view we consider merely the difficulty of the achievement; in the other, the value of the result to mankind. The first view is obvious when the thing is done; the other is to be reserved for a future day, when all the consequences have followed the original cause. The first view is that which measures the power of the man—just as the lifting of a huge weight by some Hercules exhibits his strength, even though the thing done may be, or may seem to be, useless. The capital discoveries I have named, made by Henry and Faraday, exhibited the giant's strength when they were made, and measured the men who made them. They were found at great depths below the surface, where mental vision can only penetrate by the aid of lenses constructed in advance in accordance with the very laws for whose discovery they are needed—creations of the scientific imagination, and called scientific hypotheses. In such creations Prof. Henry was excelled by no man.

Time will not permit even a hasty review of all the scientific labor done by Prof. Henry at Princeton during those years when his chief duties were instruction, and when he had only a portion of his time in which to work for mankind and for reputation; and I must be content with a passing glance at a part of it.

Among those wires which were strung across the campus in 1835 was one used for a magnetic telegraph between the Professor's home and his laboratory in the Philosophic Hall, and that telegraph line was the first in the world in which the galvanic circuit was completed through the earth—one end of the single wire circuit terminating in the well at the house, and the other in the earth at the hall. Steinheil, in Munich, in 1837, worked his electric telegraph in the same way by a single line wire, using the earth as part of the circuit over much longer distances, but it was first done in this campus.

Nearly a century earlier our great countryman Franklin had drawn from a surcharged thunder-cloud, upon the string of a kite, in a pouring shower of rain, the lightning of heaven, and had demonstrated its identity with the puny spark of an electrical machine; and with that capital experiment his fame is more closely associated than with any other of the great truths he discovered. In these grounds that experiment was amplified, and still further results obtained, by the man for whom the mantle of Franklin had been waiting all those years, and who was the only American whose stature would not have been dwarfed by assuming it.

From the clear, blue sky, with two kites, one above and assisting the other, held by a delicate wire wound on an insulated reel, Prof. Henry drew down streams of brilliant sparks, intensified by the self-induction of the wire itself, thus proving the electrical relations of the earth and its envelope. So a child's plaything in the hands of a master reveals the hidden mysteries of the universe.

Away beyond the distant horizon we see at times a quivering illumination of the sky, but hear no thunder. How shall that phenomenon be questioned? Fifty years ago Henry converted the metallic roof of his house into a great inductive plate by soldering to it a copper wire, and leading that through an electro-magnetic coil to the ground, and with that he held converse with the distant lightning so far away that its voice could not be heard. If the gods of mythology, who hurl their thunderbolts, have a system in their signals, this apparatus would enable us to read their thoughts. Within a few months a device has been put into operation by which telegraphic communication is kept up between the running cars on railroads and the stations, so that the positions of all the trains may at any time be known, and protection against collisions assured. To do this, the metallic roof of the car is used as an inductive plate just as was the house roof fifty years ago; and a wire passes from it through a signaling coil to the ground by way of the metal wheels and track. Near the roof outside, an electric wire is stretched on poles, through which electric flashes, like lightning, are sent, and they set up by induction in the roof electric currents similar to those passing over the wire, which are read as signals by the observer; and, conversely, signals are sent from to the wire by induction coils in the car. The experimental demonstration in Princeton has not been lost, though buried so long, and to-day it throws another safeguard around our lives.

The first electro-magnetic engine for generating power was made by Henry, at Albany, in 1831. His clear mind was not deluded into the belief that such an apparatus could supersede the steam engine as an economical motor, and he warned the world against that delusion. Zinc, as fuel in a battery, is more costly than coal in a furnace. Still, he saw, and said, that in exceptional cases it might be useful; a result now coming to pass, dependent, however, upon the discovery of magneto electricity, by which galvanic batteries are dispensed with, and electricity, made in quantities from some great and economical source of power, is distributed to Henry's machines wherever they may be.

In many volumes, some of which have perished by fire, and some remain, were laid out lines and plans of investigation by Prof. Henry, needing only leisure and means for their development, covering fields where investigators have since reaped rich harvests of fame, but from which he was debarred by the pressure of his other occupations here. In those records are contained the evidence that the great intellect which did so much with so little was capable of grasping the whole circle of physical science, and of enriching and adorning any department of it to which his efforts might be directed.

But he was destined for another career. A benevolent Englishman, inspired by the noble ambition to aid in elevating mankind, had bequeathed to the United States a great sum of money to be used for "the increase and diffusion of knowledge among men." It was a splendid gift and a sacred trust. Who was to be found equal to the task of effecting this grand purpose? The civilized world was interested in that question. Mankind was the beneficiary of the trust, and all men were entitled to be considered in its administration. By the common consent of the wisest and best of Europe and America, Prof. Henry, of Princeton College, was selected, and solicited to assume that onerous duty. What tribute was that to the achievements, the attainments, and the character of the man! He must be famous, that his selection might at once command the assent of the world; he must be learned, that he may be able to carry out the purpose of the donor; and he must be virtuous, that he should not degrade the high office to any base or selfish uses. And thus he was called.

When brought to the parting of the roads, choice was extremely difficult. On the one hand, a life devoted to the most delightful of all pursuits—the searching out the laws of nature, which are the thoughts of God; a reputation already great and daily growing; and a happy home, surrounded by congenial and loving friends, and undisturbed by cares for the present or the future. On the other hand, the abandonment of the field of scientific research, where the harvest was abundant and the laborers few, and a surrender to others of the prizes he saw glittering before him in the race he was running; and, furthermore, a grapple with the problems of organization and finance, and with the discordant elements which the scheme of the Smithsonian Institution would necessarily evoke. He foresaw that he might find himself, after some years had passed, like a giant shorn of his strength; on the one side outrun in the race where he had ever been in the lead, and on the other so hampered and crippled as to be unable to accomplish the great objects for which alone he was about to abandon his first love. That high sense of duty which governed him in every act of his life decided the question, notwithstanding his firm conviction that in accepting the trust he left the happiest days of his life in the past.

Perhaps he might have decided otherwise if Princeton College had been then as it is now. Perhaps he then might have felt that, with such ample resources at his command as are now to be found here, his services to humanity might be greater as a soldier in the ranks than as a commander in the field. But at that time no one had arisen among the friends of this institution who, like the Medici of the fifteenth century, was able at the same time to gather the wealth of the world by the arts of honorable commerce and to appreciate that the gathered wealth of the world owes its existence and preservation to science, to art, and to literature; and that, therefore, it is due to education that it should be encouraged by noble gifts, such as have enlarged the capacity of the College of New Jersey, and reflected honor upon the names of those whose generous hearts, guided by wisdom, have led them to broaden these ancient foundations, and to arm with improved facilities the workers who are here devoting their lives to the advancement of knowledge. All honor to such men. Had such assistance come earlier, the career of the great scientist might have been different; but it was not to be, and thenceforth another life opened before him and another man was unfolded to the world.

Perhaps the highest praise that can be bestowed upon any man is to say of him that he is just equal to all the duties ever imposed upon him, and never above them; that his reserves are not called into action until the emergency requires them. Such men are the great benefactors of mankind. Such a man was the secretary of the Smithsonian Institution. The principles he laid down for the administration of the noble gift of Smithson required time for their development, and promised no present results. The foundations were to be laid deep in the earth, where the laborer and his work were scarcely to be seen by the passer-by. No popular applause would greet the achievement for years to come, while popular clamor was ever ready to cry out against the waste of time and money that produced no instant fruits. The man of clear purpose and resolute will stood guard over the work, and with just force enough, and no more, drove off the assailants till the foundations were all secure, the superstructure begun, and it was strong enough to stand alone.

With the skill that would have adorned a professional diplomatist, he temporized and compromised when he could no longer contend with success; with the dash that would have illustrated a general, he attacked when the moment was propitious and the adversary off his guard. With the earnestness of sincere conviction, and the directness of demonstration with which his scientific training had armed him, he convinced, one by one, those who opposed his views, until at last the regents of the Institution and Congress surrendered their judgments to his, and the field was won.

A great library was the dream of Mr. Choate, the most scholarly and persuasive of advocates; and, as a regent, he possessed and wielded a formidable power. It was hard to persuade him that a library does not "increase knowledge among men," and that it is very likely to "diffuse" ignorance. To discover and accumulate new truths, and to diffuse them over the whole earth, was the secretary's conception of the donor's intention; to pile up in Washington a miscellaneous collection in print of old truths and old errors was the idea of the scholars, and they were so strong that a temporary compromise was necessary. The vigorous growth of the true conception at last overshadowed the false one, and the library no longer saps the life of the Institution. Prof. Henry always thought that over every library portal should be written some such warning as "*Cave canem*"—beware of the lies.

It was not till 1852 that the serious attacks upon the Smithsonian came to an end. On the 24th of June of that year, a United States Agricultural Convention met in the theater of the Smithsonian building. The plan to plunder the Institution seems to have been carefully considered and matured; and the officers of the Smithsonian were elected members of the Convention. Stephen A. Douglas was at that time at the height of his power. He had risen from the ranks by the arts of the politician, and was the most influential man in the Democratic party of that day. Although not yet forty years old, he had just succeeded in defeating General Cass in a contest for the Presidential nomination at Baltimore; and, although he failed by a few votes to secure it, he had thrown it to Franklin Pierce, of New Hampshire, and thus kept it open for himself in 1856, as the Western candidate of the party.

He was styled the "Little Giant"—not in derision, but in admiration; as expressing the combination of a small stature and great intellect. Representing in the

convention what was then an almost entirely agricultural constituency, he thought that votes were to be got, and his influence strengthened, if he could bring home to them the spoils of the Smithsonian; and, accordingly, a resolution was introduced petitioning Congress to appropriate a portion of the Smithsonian money for an agricultural bureau; and Judge Douglas undertook the congenial task of accomplishing the raid. The recollections of that battle are among the valued treasures of memory associated in my mind with Joseph Henry. In such an assemblage, and with such a cause, Douglas was an adversary to be feared by any man. That he was an accomplished politician was proved by his great success; and he was there to fix another step in the ladder by which he had climbed so high. His speech was adroit as only he could make it. Its argument was founded upon the proposition that civilized man depends upon agriculture, without which barbarism would sweep over the land; and his conclusion was that the farmer was entitled to whatever assistance could be got out of the money of Smithson, whose benevolence could best be applied in encouraging those who were at the very foundations of civilization. It would be great injustice to Judge Douglas to assume that he supposed the diffusion of papers of turnip seed among farmers was that sort of "increase and diffusion of knowledge among men" designed by Mr. Smithson; but, no doubt, it would be an increase and diffusion of the knowledge that he was the friend of the farmer, and that was of more importance to him. The secretary, surrounded by a few earnest friends, and prepared for the assault, sat in the back seat of the theater, quite unnoticed, kindling with righteous indignation at this nefarious plot to confiscate the funds of which he was the chosen guardian, and to destroy the institution devised by his intellect, reared by his unceasing efforts, and guarded so far by his sleepless vigilance.

When the popular applause following the "Little Giant's" popular speech had subsided, the secretary arose. In measured and dignified words he presented himself as the guardian of that fund, bound, so far as in him lay, to defend it from spoliation. He first developed the moral aspects of the question, and appealed over the head of the advocate to the honesty of the constituents he represented, expressing the most generous confidence that the farmers of this country would never consciously be parties in an attempt to seize that which belonged to mankind in general, or seek by a forcible partition to destroy the unity and efficiency of the fund.

The legal aspect of the question he next discussed like an equity lawyer, and denounced in scornful sentences that attempted breach of trust which was implied in the resolution.

And then, out of that fullness of his knowledge, with abundance of illustration and example, he demonstrated that the discovery of new truths, and their application to the arts, had elevated the farmers from the mere drudges they were in the seventeenth century to their present high state of intelligence and comfort.

The effect was overwhelming, and the "Little Giant" must have felt that there was another "giant" there, to whose title no diminutive prefix could be properly applied.

The meeting adjourned till the next day, and these significant words were written in the secretary's diary, under the date of June 25: "Judge Douglas, toward the close, made an apology for the warmth of his expressions. I did the same. Judge Rusk followed; so the whole was amicably settled."

Since that day, no further assaults have been made on the Smithsonian Institution; and it stands a proud monument to the genius, the learning, the labor, and the character of the great secretary who was content to sink his personality in the impersonal institution—to be overshadowed by the creature of his own creation, in order that true knowledge might the better be increased and diffused among men.

The conscientious obligation he felt pressing upon him to lose no opportunity for diffusing knowledge and correcting error imposed a vast amount of unrecognized and unrequited labor. The intellectually halt, and lame, and blind continually resorted to him for help, either in person or by letter; and they never were sent away empty. Like the home of the lonely country parson in the Deserted Village,

"His house was known to all the vagrant train;
He chid their wanderings, but reliev'd their pain."

Those who have witnessed some of those deeds of charity will never forget the gentle patience with which he listened to the beggars for knowledge, and the simple way in which he conveyed to their imperfect intelligences the truths they were seeking. Their self-conceit was often offensive; but he knew it was the product of ignorance, and his effort was to cure the disorder. He was no more repelled by the disagreeable symptoms than the physician is who must treat a loathsome disease. On one occasion, in my presence, one of these cripples refused to accept the instructions of the great physicist on a very simple question of dynamics, applicable to a project he had in hand; but instead of dismissing him, the master quietly took down "Hutton" from the bookcase, and patiently read that author's confirmation of the law he had been teaching. What an exhibition of true humility! "Perhaps," thought he, "I can give a new direction to this man's mind, who may yet do something useful; and what matters it that he scorns me?"

No one can form an adequate estimate of the vastness of his mind, of the extent and accuracy of his learning, and of his power to discern the correlations of knowledge, who has not carefully read the instructions mapped out by him for the guidance of investigators working under the auspices of the Smithsonian Institution. They constitute a set of charts which for years to come will guide the explorer safely and surely in future voyages for the discovery of new truths, and are a monument attesting the fidelity with which the great trust was executed, and vindicating the sagacity of those eminent men who in 1846 saw what his innate modesty forbade him to see, that Joseph Henry was, of all living men, the most fit to administer a fund whose object was "the increase and diffusion of knowledge among men."

Passing by thus hastily the great achievements illustrating the long and happy life of Henry, let us examine with more particularity his connection with the electro-magnetic telegraph, whose creation has so largely modified the course of modern civilization, and endowed the full earth with nerves like those of the living frame, whereby the whole body of mankind instantly feels the joys or sorrows of any of its members.

How to communicate intelligence instantly, over distances so great that the voice cannot be heard, had been well known to organized societies from remote antiquity. Visible signals made by moving vanes by day and lighted torches by night were known to Greeks and Romans alike; and more recently the alphabet was associated with these movements, so that alphabetical messages were freely communicated.

Even barbarous nations and tribes possessed this art in a high degree of perfection; and the arrival and progress of Cortez in Mexico were communicated by telegraphic signals, corresponding with the sign language of the Aztecs, to the capital of the doomed Montezuma.

When atmospheric electricity came to be artificially generated, it occurred at once to ingenious men that it might be used for telegraphy; and, in 1774, the first electric telegraph ever constructed was established at Geneva by Lesage. He used twenty-four wires, each connected with an electroscope, whose function it is to move when the wire is charged with electricity, and by means of which any of the letters of the alphabet could be transmitted by simply discharging a prime conductor of an electrical machine into the wire corresponding to that letter.

This complicated apparatus was subsequently improved by using only one wire, and causing lettered wheels to revolve synchronously at the two stations, so that the same letter would appear at the same time to both operators. By this apparatus, whose principle of synchronous revolution is the same as that used in the printing telegraph, the sender would simply close the circuit on his electrical machine when his revolving wheel presented the desired letter, and the pith ball electroscope, moving at the receiving end at the same instant, would indicate to the receiver that the letter then presenting itself to him on his wheel was the one intended.

A number of other inventors used static electricity for the same purpose during the latter years of the last century and the earlier ones of this. In England, Ronalds had a line of eight miles on which the wire was suspended from poles, and insulated by silken strings; and in 1796, Salva, in Spain, worked a line by static electricity twenty-six miles long.

In the year 1800 Volta produced the voltaic pile, and gave to the world that new manifestation of electricity called galvanism. In that form this subtle agent is far more manageable than in the form of static electricity; and by the use of galvanic batteries a current of low tension, but of enormously greater power, can be maintained with little difficulty; whereas static electricity is like lighting, and readily leaps and escapes on the surfaces on which it is confined. The galvanic current also readily decomposes acidulated water and many other substances, and this capacity was soon applied to the purposes of telegraphy. Soemering, in 1807, invented a telegraph on this plan, and continued it for several years in Munich, publishing accounts of it in scientific journals, and exhibiting it to learned societies. Others followed his lead, until finally it came into commercial use in England in 1846 as a rival to the electro-magnetic telegraph of later invention, but requiring its aid as an alarm.

In 1820 Oersted discovered the capital fact that a galvanic current passing through a wire placed horizontally above and parallel to an ordinary compass needle will cause that needle to sway on its axis to the east or west, according to the direction of the current through the wire. At once Ampere suggested the application of the new discovery to the old telegraph, whereby galvanism might be substituted for static electricity, and the deflection of a magnetic needle for the divergence of the pith balls of the electroscope. Baron Schilling, a Russian nobleman, inspired by the love of science, accordingly took up his suggestion, and constructed a galvanometer or needle telegraph, which in a practical and operative form was exhibited to the Emperor Alexander in 1824, and came to be well known to scientific persons at that time.

In 1833 Gauss and Weber set up a single circuit galvanometer telegraph on this plan at Gottingen, leading the wire over the housetops on insulators, as we do now, and by the deflections of the needle to the right and left made up the alphabet, as it had been done before when using other means for moving the vanes.

Their apparatus, however, is perfectly silent. The needle is suspended by a thread, when the noiseless current sways it to and fro with but little force, and it is incapable of calling the attention of the operator to receive its message. These were serious difficulties, to be overcome by other principles and other inventions, which would supersede this one.

Following Oersted, Arago, in France, in 1820, made the next capital discovery. It was but a little thing he saw—simply that a sewing needle, surrounded by a coil of wire through which a voltaic current passed, had become magnetic, but that little thing has grown to be mighty. This observation was the complete discovery of electro-magnetism, which had been dimly seen in Oersted's galvanometer, and was the germ of the electro-magnet. For four years this beautiful discovery was experimented with by all the scientists in Europe before another step was taken; and then William Sturgeon, of England, produced the electro-magnet. It consisted of a large soft iron wire, bent into a horseshoe form, coated with varnish, and wrapped with a spiral coil of naked copper wire from end to end, through which the voltaic current might be passed. This bent wire became a magnet while the current flowed, but lost its magnetism when the current ceased.

Here, then, was born into the world an apparatus capable of exerting a stronger power at the will of the operator, by merely opening and closing the voltaic circuit; and it was then thought that the difficulties in the way of the telegraph were conquered. The experiment was soon tried with Sturgeon's magnet by Barlow, an eminent scientist; and in January, 1825, he published his results in the *Edinburgh Philosophical Journal*, in these words:

"The details of this contrivance" (a telegraph) "are so obvious, and the principle on which it is founded so well understood, that there was only one question which could render the result doubtful, and this was, Is there any diminution of effect by lengthening the conducting wire?" If not, he proceeds to say: "Then no question could be entertained of the practicability and utility of the suggestion above adverted to. I was, therefore, induced to make the trial; but I found such a sensible diminution with only two hundred feet of wire as at once to convince me of the impracticability of the scheme."

Barlow's experiment was repeated by other scientists in that and following years with a like result, until it came to be accepted in the scientific world that the telegraph could not be worked with the newly discovered electro-magnetism. So strongly was this fixed in the opinion of the day, that as late as 1837—thirteen years after the invention of the electro-magnet by Sturgeon—so eminent a scientist and discoverer as Wheatstone pronounced the electro-magnetic telegraph impossible, on an occasion when the very question was submitted to him for decision by Cooke, at the suggestion of Faraday himself. This fact is so important, and so conclusive on the question now under examination, that I read Wheatstone's own account of it, submitted by himself to arbitrators who were to decide a controversy between himself and Cooke as to their respective merits as inventors of one form of the electro-magnetic telegraph. He says:

"I believe, but am not quite sure, that it was on the first of March, 1837, that Mr. Cooke introduced himself to me. He told me he had applied to Dr. Faraday and Dr. Roget for some information relative to a subject on which he was engaged, and they had referred him to me as having the means of answering his inquiries. . . . Relying upon my former experience, I at once told Mr. Cooke that it would not, and could not, act as a telegraph, because sufficient attractive power could not be imparted to an electro-magnet interposed in a long circuit; and to convince him of the truth of this assertion, I invited him to King's College to see the repetition of the experiments on which my conclusion was founded. He came, and after seeing a variety of voltaic magnets, which, even with powerful batteries, exhibited but slight adhesive attraction, he expressed his disappointment."

Cooke confirms this statement by saying: "It was my inability to make the electro-magnet act at long distances which first led me to Mr. Wheatstone."

Let the difficulty of making the discovery which overcame this impossibility be judged by the fact that for so many years such men as these were unable to do it when it was needed; and let that fact answer the envious suggestion that Henry's achievement involved no great amount of analytic and inventive power.

When Barlow's demonstration was published in 1824, Henry had never seen an electro-magnet, nor tried an experiment in electricity. When, however, two years later, he took up the subject, and began the first set of regular scientific investigations ever attempted in the United States, he deduced from Ampere's law the principle that the voltaic currents, carried on wires around the iron core of the electro-magnet, should move in planes at right angles to the axis of that core, which they could not do even approximately if the core itself were insulated, as in Sturgeon's small magnet, having only one coil of naked wire wound spirally around it, necessarily leaving open spaces between the successive spirals, and so leading the current like a corkscrew around the core. He also reasoned that, as the current must be led through a spiral circuit, which theoretically should be circular, the departure from its true course might be counteracted by winding the wire on a second spiral outside of the first, but with its spiral angle opposed, so that the resultant of the current from the two spirals would be the same as if it revolved in planes at right angles to the axis of the core.

He brought his reasoning to the test of experiment. Instead of insulating the core, he wrapped a fine copper wire with silk, and wound it on the core—each spiral closely packed against its fellows, so as to correct the spiral error as much as possible in each layer; and then he wound the wire in a second spiral over the first, but with the pitch of the screw, so to speak, in the opposite direction. And carrying out the principle, he multiplied the coils to an enormous extent in the same way. The result justified and established his theory, and his magnets at once showed a capacity hundreds of times greater than any then known to science.

But this was not all. Another step had to be taken before Barlow's demonstration could be overthrown, and the telegraph made possible. And this he took by discovering and establishing the fact that a magnet with a long fine wire coil must be worked by a battery of "intensity," composed of a large number of cells in series, when a distant effect was required, and that the greatest dynamic effect, close at hand, is produced by a battery of a very few cells of large surface, combined with a coil or coils of short coarse wire around the magnet.

These discoveries and inventions solved the problem which had seemed to European scientists insoluble, and in one account of them, which was published in *Silliman's Journal* for January, 1831, he says: "The fact that the magnetic action of a current from a trough is at least not sensibly diminished by passing through a long wire is directly applicable to Mr. Barlow's project of forming an electro-magnetic telegraph." This reference was to Barlow's paper of 1824, in which he had demonstrated the impracticability of the telegraph.

Had these things been done in the Royal Institution, and read before the Royal Society, Wheatstone would not have been found, in 1837, denying the possibility of an electro-magnetic telegraph; and Faraday would have been able to answer Cooke's question without sending him to Wheatstone for the information. In those days, however, the United States were held in no higher estimation in Europe than Nazareth was in former days in Jerusalem, and no one in England read an American book.

But not content with having reasoned out, and demonstrated, that distance was no longer the sole impediment in the way of the magnetic telegraph, Henry, in 1831, established the first electro-magnetic telegraph that ever existed. In the Albany Academy he strung a mile of line wire, and with an "intensity battery" at one end, and his spool of long fine wire at the other, he operated the armature of the first sounding telegraph of any kind. When the armature was attracted by the magnet, it struck a small bell or sounder, which

spoke its signals; and that apparatus there was maintained to illustrate the telegraph to the students.

When applied to practical use, some code of signals must be arranged for translating the successive taps of the armature; but that was well known in the telegraphic art for ages, needing only good judgment in arranging it, so that the letters which occur most frequently shall be represented by the smaller number of motions, just as Gauss and Weber arranged their needle telegraph code in 1833, when the movements of their needle to and fro, in a number of simple combinations, indicated the alphabet.

These "spools" of Henry have been the means by which most of the great discoveries in electro-magnetism have since been made. Faraday and Henry used them in their famous researches already referred to, in which they discovered magneto electricity. Sturgeon in writing of them says: "Prof. Henry has been enabled to produce a magnetic force which totally eclipses every other in the whole annals of magnetism, and no parallel is to be found since the miraculous suspension of the celebrated Oriental impostor in his iron coffin." Without them we could not have the telegraph or the still more marvelous telephone. They are to-day essentials of modern living, and are as familiar to us as spools of cotton. Judging by their results, they constitute the most important discovery which has ever been made in electricity since Volta created the battery.

Henry also put in operation at Princeton, in 1835, the very simple and obvious plan of using the "intensity spool and battery," working through long distances, to open and close the circuit of "quantity spool and battery," stationed where the work was to be done, thus making the powerful magnet, at short range, the servant of the weak one at long range. In this state he left the problem entirely solved, to those who could procure the money to practically apply his discoveries to the commercial uses of man.

That task was no easy one. In 1831 there were no railroads and no steamships. Over rough country roads the mails were carried in wagons or coaches, and the postage on a single letter was a shilling for short distances, and twice as much for longer. But little capital had accumulated in this country; and corporations—those powerful instruments for uniting the slender means of the many into a compact force for the development of great industrial enterprises—were hardly known. If the most perfect telegraph apparatus of to-day had been presented to the public, no company could have been formed to exploit it. The time had not yet come, nor could it come until railroads were built, and the exchange of material things had been rendered easy.

In Europe, where money and railroads were more abundant, the telegraph was first put into practical use. Wheatstone and Cooke, in England, in 1838, having first, however, seen and talked with Henry on the subject in 1837, after they had first decided the thing to be impossible, established a practical commercial telegraph line between Paddington and West Dayton, a distance of thirteen miles; and a shorter line was in Munich. In this country private capital could not be raised for the purpose at all, not because there was any doubt that the thing could work, but because no one supposed it would repay the investment, as it certainly would not have done in those early days. At last Congress was induced to do what private enterprise refused, and in 1844, six years after the English lines had been in practical operation, and seven years after the Bavarian, money was appropriated for the line between Baltimore and Washington. This was accomplished, after great exertions, by persons hoping for the reward which a patent for some of the contrivances connected with that particular plan promised.

Neither in England, where Wheatstone had a patent founded on Henry's inventions, nor here, where Morse had a similar one, could the telegraph have been introduced for years after it really was, but for the beneficent operation of the patent laws. But few men are to be found who will incur the risks, and expend the money, incident to the introduction of a new and untried industry, without the hope of that pecuniary return which in such cases can only be secured by the exclusive use for a "limited time" of the new thing, during which it is hoped the original losses may be repaid and a profit earned.

Let us now consider what would have been the position of Henry in the world if, at any time before his inventions had been so long in public use that he had lost his rights, he had taken a patent for—

First, his magnetic spools, pure and simple.

Secondly, the combination of a magnetic spool of long fine wire with an "intensity battery," for the purpose of producing a practical magnetic effect at great distances.

Thirdly, the combination with such an apparatus of a quantity battery, operating upon a spool magnet of coarse and short wire, at a distance from the intensity battery, whereby the great lifting power of the quantity magnet might be controlled by the intensity combination.

And finally, the combination of the intensity battery and spool with a vibrating armature, so arranged as to strike a sounder when the circuit is closed or opened at the sending end, for the purpose of transmitting intelligible messages telegraphically.

All these he might have patented in the United States at any time during several years after his discoveries and inventions were made; and he could have held them against the world. That he was the first man to do all these things is not in doubt anywhere. If he had taken such a patent as late as 1837, he would have controlled the telegraph in this country, certainly until 1851; and unless he had then been adequately rewarded for his great inventions, his term would have been extended till 1858. Imagine the good he would have done to science had the wealth which this would have produced been poured into his purse! But listen to his noble words: "At the time of making my original experiments in electro-magnetism in Albany, I was urged by a friend to take out a patent, both for its application to machinery and to the telegraph; but this I declined, on the ground that I did not then consider it compatible with the dignity of science to confine the benefits which might be derived from it to the exclusive use of any individual."

Pure science was his beloved, and he could not make merchandise of her.

When that sentence was written, other eminent scientists had thought differently of this question, and had patented their discoveries; and, lest he might seem to cast a reproach upon them, and to say, "I am holier than thou," his humble spirit added these words: "In this, perhaps, I was too fastidious."

It must have occurred to him at times, when he needed money for his experiments, and when he saw the fruits of his labor enriching the world, that he might have taken some share of the wealth; but he would not taint with selfishness his generous gift. How valuable in money it was he knew full well. Even for that fragment of it then for six years by him given to the public, which was carried to Morse in 1837 to enable him to construct his special plan of a recording telegraph in that year, now practically obsolete, Dr. Gale, who carried it, received a share in the patent which was founded upon it, and without which it could not have existed. For that share fifteen thousand dollars in cash were subsequently paid to him. And its use for the telegraph was but a small part of its infinite variety of applications to the arts and the purposes of man.

Come with me now into a telegraph office, and let us see what we find there. If the line be a short one—say thirty or forty miles—you will see but one of Henry's spools, fixed to a table, having a piece of iron called an "armature," capable of vibrating in front of its poles, and so arranged that when the "spool-magnet" attracts it, it will vibrate, and strike a sounding-bar of sonorous metal, which gives out distinctly the sound of the tap.

The "spool" is wound spirally in layers with several hundred feet of fine copper wire, covered with silk, in the manner specified by Henry in *Silliman's Journal*. At the other end of the line is a battery, composed of a number of cells in series, called by Henry for distinction an "intensity battery;" and the wire circuit is supplied with a simple device, so that it may be opened or closed by the operator's finger. When he closes it, a current of electricity flows from the "intensity battery" along the wire and around the coil of the "intensity magnet," and the armature strikes the sounder and gives the signal. The listener hears it, and as the order of the taps progresses in accordance with a prearranged artificial code, to express the letters of the alphabet by combinations of successive taps—just as the old visible signals were arranged by combinations of the successive movements of the vanes, or afterward of the needle of the Gauss and Weber telegraph—he hears letter after letter tapped out, and the message is understood.

Now, that apparatus has nothing about it more than was in Henry's Albany telegraph of 1831; nor could it operate if it omitted any one of the inventions, either singly or together, which were then for the first time combined. It depends entirely upon the discoveries made by Henry before 1831, and it could not have existed in the world earlier than those discoveries, by the use of any means then known to man, nor since by any other means than those discovered by Henry.

Henry used a bell as sounder; they now use a metal bar and a sounding box. Henry reversed the battery current, whereby no spring is needed to withdraw the armature for the purpose of vibrating it; and that is the common practice in English and German telegraphs. Here they generally merely interrupt the circuit, and the armature is withdrawn from the magnet by a spring, although Henry's device is also used here largely, and is essential to the quadruplex instruments.

If, however, the telegraph line is a long one—it may be a thousand miles or more—then you will see two sets of Henry's spools and two batteries. One is the "intensity battery and spool" first described, and the coil of fine wire may be, and often is, several thousand feet long, while the battery is composed of more than a hundred cells. The distance being so great, they do not attempt to send force enough through the intensity circuit to operate a sounder, but only to open and close the local circuit of Henry's quantity battery and spool. That circuit consists of a battery of but one or two cells of a large surface, and a spool with about a hundred feet of coarse wire wound around its core. The intensity combination opens and closes this quantity circuit, whose armature strikes the sounder, just as the intensity armature itself does on shorter lines. This obvious plan Henry described and exhibited in Princeton to his classes long before any magnetic telegraph was ever commercially constructed, or the convenience of such an arrangement had resulted from the great length to which the lines are stretched.

Upon that apparatus there are but four names to be written—Oersted, who discovered the effect of the voltaic current upon the magnetic needle; Arago, who discovered that the voltaic current could generate magnetism; Sturgeon, who produced the first electro-magnet; and Henry, who discovered the conditions under which an electro-magnet might be operated at a distance, who invented the devices by which it could so operate, and who applied those devices to an operative telegraph, of the same form and substance as that now in use all over the world. Beyond their discoveries and inventions nothing is essential to the present telegraph, except that which was of common knowledge when those discoveries were completed, and that ordinary mechanical skill which is far below the level either of discovery or invention.

This is the record, and so it will stand forever.

"The moving finger writes; and having writ,
Moves on: nor all your piety nor wit
Shall lure it back to cancel half a line,
Nor all your tears wash out one word of it."

Forty years had fled away since as teacher and pupil we first met, and they seemed like a dream that is past, when again we met to part forever in this world. In the chamber where the angel of death hovered over him just ready to call him away, he talked thankfully of the past and hopefully of that eternity on whose verge he stood. The vigor of youth and manhood had been all spent in the service of humanity, and his strength was gone. The pallor of disease had dispelled the delicate hues of health, and time had traced its furrows on his brow. But the unclouded intellect still held its sway, enthroned in that magnificent head on which the snows of many winters had drifted; and the gentle, loving spirit still, as of old, illumined his beautiful face, but with a clear, warmer light, reflecting the heaven upon which he gazed. For himself he had but one regret—that he had not been spared to complete his last great labor, by which he hoped to confer still one more benefit upon humanity, by discovering some means affording greater security for mariners on the treacherous coast, when fogs draw down their impenetrable veils over the lights, and the siren's voice fails to pierce the fickle air.

The faithful servant—faithful unto death—only mourned that he could not have done more. With the humble spirit of the true Christian, after having in the estimation of his fellow-men done so much, he, knowing better than others how much was yet to be done, exclaimed, "I am an unprofitable servant."

Such a life and such a death exalt and glorify humanity; illustrating and indelibly impressing upon our hearts the sublime truth that man is made in the image of God.

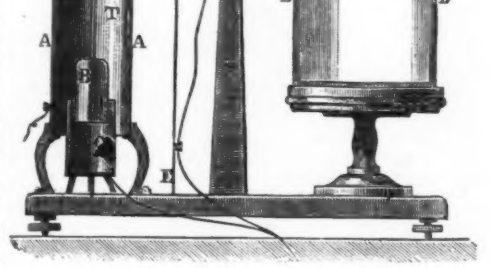
"Along the smooth and slender wires the sleepless heralds run,
Fast as the clear and living rays go streaming from the sun;
No peals or flashes, heard or seen, their wondrous flight betray,
And yet their words are quickly felt in cities far away."

AN ABSOLUTE ELECTROMETER GIVING CONTINUOUS INDICATIONS.

By MM. E. Bichat and R. Blondlot.

We have constructed an electrometer founded upon the attraction of two concentric cylinders, and which enables us to measure potentials in absolute values. This electrometer has the double advantage of being easily constructed and of giving continuous indications.

An insulated cylinder, A A, is connected to the source of the current whose potential is to be measured. A cylinder, B, the axis of which coincides with that of the former, is suspended by the rod, T, to the



scale, P, of a balance, and communicates with the ground by means of the beam of this balance. The cylinder, B B, plunges in part into a cylindrical vessel, C, rather larger in diameter and communicating likewise with the ground.

A screen, E E E, connected with the ground, allows the rod, T, to pass through an aperture it; serves to protect the balance against the attractions of the cylinder, A A.

The cylinder, A, exerts upon the cylinder, B, a force directed from below upward, which may be valued by following a procedure analogous to that employed by Maxwell for establishing the theory of Sir W. Thomson's quadrant electrometer. The totality of the cylinders, B and A, forms a condenser; the length of these cylinders being sufficiently great in proportion to their diameters at the mean part of the cylinder, B, and at the corresponding part of A, the distribution is the same as if they were infinitely long, that is, in this region the equipotential surfaces are concentric cylinders and the lines of force are the radii; above and below, the distribution is different. If we suppose that the cylinder, B, projects out of C, by a quantity which is not too great, we may consider the change in distribution as having consisted in a simple prolongation of the portion in which the distribution is the same as if the cylinders were indefinite, the portion situate above, where the distribution is irregular, being simply displaced.

Let B and r be the respective radii of the cylinders, A and B; V the potential of A, that of B being zero; let, further, F be the force which attracts the cylinder, B, from below upward. Let us suppose that the cylinder, B, is raised by a quantity, $d\,z$; the work of the electric forces is then $F\,d\,z$. According to the theorem relative to the displacement of bodies of a constant potential, this work is equal to the increase of energy of the system. But the increase of charge is the product of V by the capacity of a portion of an indefinite cylindrical condenser of the height $d\,z$; it is therefore equal to

$$\frac{1}{2}\,\frac{V\,d\,z}{L\,\frac{R}{r}}$$

In consequence the increase of energy is

$$\frac{1}{4}\,\frac{V^2\,d\,z}{L\,\frac{R}{r}}$$

and we have the equation

$$F\,d\,z = \frac{V^2\,d\,z}{4\,L\frac{R}{r}}$$

Whence $$V^2 = 4\,F\,.\,L\,\frac{R}{r}$$

If we measure R and r in centimeters, and F in dynes, we shall have V^2 in absolute units of the C. G. S. system.

To measure F, we put marked weights upon the scale, P, of the balance, until the equilibrium is re-established.

The value of these weights expressed in grammes, multiplied by the number g, gives the force expressed in dynes.

In order to annul the oscillations of the beam, we suspend in the place of the second scale of the balance a large pasteboard disk, which rises and falls in a glass cylinder, D D, of a rather larger diameter. The friction of the air renders the apparatus almost aperiodic.

The force, F, being, within wide limits, independent of the position of the cylinder, B, it results that we may also make use of this instrument without employing weights, by merely observing the inclination of the beam. A mirror, M, fixed above the knife edge, enables us to measure this inclination by the process of reflection. When the equilibrium is established, F is equal to a constant multiplied by the tangent of the angle of inclination. This constant is determined, once for all, by putting in the scale, P, a known weight, the electrometer being discharged, and observing the corresponding deviation.

For small deviations the force, F, is proportional to the number of divisions which have passed before the cross wires of the telescope. A counterpoise, Q, movable along a needle fixed perpendicular to the beam, enables the sensitiveness of the balance to be modified at will.

A calculation based upon the formula given by M. Blavier for the capacity of a condenser formed of two cylinders whose axes do not coincide, but are parallel, shows that a lateral displacement of the cylinder, B, even of two or three millimeters, has only an exceedingly small influence upon the value of the force, F. This is because F is at a minimum when the two cylinders are concentric. In our apparatus, where R = 5·875 centimeters and r = 2·5 centimeters, F varies only by 0·003 of its value for a deviation of the axes of three millimeters.

In the calculation made above for determining F, the rod, T, supporting the cylinder, B, has not been taken into account. The complete expression for F is obtained by deducting from the action upon B that which is exerted upon the rod. If we call ρ the radius of the latter, the factor by which we must multiply, the force to obtain the square of the potential is

$$4\left(\mathrm{L}\frac{\mathrm{R}}{r}-\mathrm{L}\frac{\mathrm{R}}{\rho}\right)$$

As a verification of the exactness of the indications of our apparatus, we have determined the potentials corresponding to a certain number of explosive distances between two spheres; the numbers obtained agree perfectly with those determined with great precision by M. Baille.—*Comptes Rendus.*

THE NEW INVENTION OF THE MESSRS. BELL.

PROF Alexander Graham Bell and his cousin, Dr. Chichester Bell, of Washington, have recently made a very remarkable discovery, which they think is quite as important as the transmission of the tones of the human voice through the telephone. They have discovered that a falling jet of water or a flame of gas burning in a room reproduces every word spoken and every sound uttered within a given distance. When two people join in conversation in a room in the evening, the gas which burns above their heads repeats every word they say, and sounds uttered in the vicinity of flowing water produced vibrations.

In the few years of its active existence the telephone has become so much a matter of course that very few remember the fascination it had for them when they first talked through it or heard the faint, distant voice, which some one said sounded "just like your conscience." The same feeling of stepping beyond the border of recognized natural phenomena attaches quite as much to this new invention.

The elements concerned are a stream of water, sunlight, and a glass plate. What it does, according to the published descriptions, is to record conversation by photographing the waves of sound, and from this photograph to reproduce corresponding waves—that is, the conversation that has been printed on the glass plate. The phonograph, to be sure, attempted this, but it depended on mechanical means that were not prompt and delicate enough to secure a satisfactory success.

It is well enough understood that whatever can repeat the waves of air produced by any loud sound will repeat the sound itself. It is the principle of the telephone. But in the telephone the original impulses are repeated instantly, and die away forever. In this new apparatus, assuming that it really does all that is described, the waves are not reproduced in that form, but their effect on a jet of water, long known to be sensitive to such impulses, is caught by instantaneous photography, and permanently recorded on a glass plate in the form of minute irregularities of surface. By suitable apparatus these elevations and depressions, which correspond to pulsations of air, are retranslated into air waves, and the voice is heard again. The water, or liquid of whatever kind it may be, is colored with bichromate of potash. If it were perfectly clear, it would not answer, because the light used in photographing would pass through without resistance, and no record would be made on the tablet. The water is colored for photographing, and the jet is made to fall obliquely on a glass plate. The water spreads itself out on the glass plate, and runs off. It is the water so spread out that is to be photographed as it passes. Words spoken cause the jet of water to vibrate, the vibrations in the jet cause corresponding vibrations in the film of water as it breaks and spreads on the glass plate and runs off. A ray of light is passed through that film and through the glass plate to a sensitive tablet behind. The vibrations in the liquid film are reflected in the variations of intensity of the impression made on the photographic tablet. Speaking continues, the jet keeps running, the film keeps passing over the plate, the recording tablet keeps moving as the film keeps moving, and the light, passing through this film to the tablet, makes a record of the speech far more accurate than any verbatim report.

The wonders worked by photography within the last few years will prepare any one familiar with them to look hopefully for the success of this attempt.

Prof. Bell considers this discovery quite as important as that of the telephone, and his cousin, Chichester Bell, has gone to Europe for the purpose of bringing it before scientific men in England and on the Continent. Patents have already been obtained in all the principal countries of both continents.—*Electrical Review.*

BARON PAUL SHILLING.

THE centennial of the birth of Baron Paul Shilling was celebrated at St. Petersburg on the 2d of May. Baron Shilling is claimed by his countrymen to have been the inventor of the electro-magnetic telegraph, but until recently his name has been almost unknown to the general public. He was a descendant of an ancient and noble family, holding many estates near Kaustadt. His father, having emigrated to Russia, and entered the military service, the Baron Paul was born in Revel, in the year 1786. By special order of the Emperor Paul I., he received, at the age of nine, an ensign commission in a regiment of riflemen, of which his father was the commander. After the death of the father, the youthful officer entered the First Military Academy, and in 1802 graduated as lieutenant in the royal suite.

The following year he was transferred to the Ministry of Foreign Affairs, but during the Napoleonic wars he returned to his regiment, took part in many battles, and was present at the entrance of the Russian army into Paris. After this he again entered the Ministry of Foreign Affairs, and was commissioned to visit Mongolia and the Chinese borders. He studied the Chinese language with care, and collected a great number of Mongolian, Thibetan, and Chinese manuscripts, which now form a special collection in the Scientific Museum of Russia.

BARON PAUL SHILLING.

In 1832 Baron Shilling invented an important improvement on the telegraphic apparatus of Ampere. In 1836 he received a written invitation to construct a telegraph line in England. He refused, however, as he wished to introduce the invention first in his own country.

Spending all his means for the purchase of books and scientific apparatus, Baron Shilling died on the 6th of August, 1837, a poor man, and was buried at the expense of his relatives. In an out of the way corner of the Protestant section of the Smolensk Cemetery, at St. Petersburg, there stands a modest monument bearing this inscription: "Here is buried the State Counselor, Paul Ivowitch Shilling."

Such was the fate of the Russian scientist who did so much for the development of the electro-magnetic telegraph. His invention was appropriated by others, and he himself died in poverty. At the present time ten submarine cables cross the Atlantic, and 2,031,054 miles of telegraph wires are used to transmit the world's news. In Russia alone, according to the latest statistics, 66,100 miles of line and 155,295 miles of wire are used, 11,000 persons are employed in operating the lines, and the government gains from this source a yearly revenue of $4,000,000.

We are indebted to *Universal Illustration* for our engraving.

A BOX was received at the Government Redemption Office the other day which contained scraps of burnt paper, which the sender said had been bills amounting to $10,000, which had accidentally been burned, and which he wanted redeemed. It did not take an expert long to determine that the contents of the box were pieces of common writing paper and a few two dollar bills that had been burned and mixed.

THE ROYAL SOCIETY SOIREE.

THE President and Council of the Royal Society are to be entirely congratulated on the success of the reunion at Burlington House on the 12th of May. It was generally felt that the display of objects of interest was finer than any brought together for some years, and the general satisfaction expressed must have amply rewarded those upon whom the burden of the arrangements had fallen.

It is a little hazardous to say which was the most interesting object; but as an *actualite*, the unpaired parietal eye of Sphenodon exhibited by Mr. Baldwin Spencer, fully described in last week's *Nature*, perhaps bore the palm.

Next in biological interest came an exhibit by Mr. W. H. Caldwell including a complete series of the Ceratodus from the unsegmented egg to hatching. The complete exhibit illustrated early stages in development of the Monotremata—Ornithorhynchus and Echidna, the Dipnoid Ceratodus and some marsupial genera. The series were as follows:

(1) Series of early stages of Ornithorhynchus, from a few hours after fertilization to the newly laid egg, of about the stage of a 36 hour chick; (2) series of early stages of Echidna, from just before laying to the newly hatched fœtus; (3) various stages of young Echidna, from hatching up to 5 inches long; (4) complete series of Ceratodus, from the unsegmented egg to hatching; (5) stages of young Ceratodus after hatching; (6) series of about thirty stages, from segmenting egg up to birth, of *Phascolarctos cinereus;* (7) ditto of *Halmaturus rufus;* (8) specimens showing the arrangement of the embryonic membranes in *Macropus major.*

There were two exhibits of micro-organisms—one of micro-photographs of bacteria, and another of certain micro-organisms themselves—by Mr. Cheshire. The former included enlargements, from negatives obtained with an oil immersion $\frac{1}{12}$ inch, of the following:

Anthrax bacillus, in tissue sections and cultivations; hay bacillus; bacillus of malignant œdema; micrococcus of pneumonia; tubercle bacillus; bacillus of foul brood; *Bacillus megatherium; Clostridium polymyxa;* microbe of chicken cholera; comma bacilli of Koch, Lewis, and Tinkler; bacteria of putrefaction.

Mr. Cheshire exhibited (1) *Bacillus alvei* in sporulation; (2) *Bacillus alvei* spores in chain; and (3) spermatozoa of Apis forming in flocculent masses for packing in spermatophore.

Preparations illustrating the histological structure of the secretory tissues of certain plants, in which the substances secreted are of economic importance, were exhibited by Mr. W. Gardiner. Among these were hairs of leaf of *Flemingia Grahamiana*—wurras dye; laticiferous vessel of the stem of *Manihot Glaziovii*—ceara rubber; glands of the leaf of *Cinnamomum Camphora*—camphor.

In connection with biological inquiry may be specially mentioned Mr. Frank Crisp's demonstration of a new microscopic object glass, by Prof. Abbe of Jena, an exhibit rich in hope not only for the future of microscopy, but also for astronomy. Eight of the ten lenses of this objective are made of a new kind of optical glass composed of phosphates and borates without silex. The glass hitherto used contains as essential components only six chemical elements, while the new objective contains not less than fourteen. The secondary spectrum is by this means entirely removed, and only a small tertiary spectrum remains. The improvement in definition is especially marked in the case of bacteria and other minute micro-organisms.

As representing this last-named science, we may specially mention a magnificent collection of the photographs of sun, stars, and planets which have recently astonished and delighted astronomers. The collection included specimens of the results recently obtained by the Dr. Janssen, the Brothers Henry, Mr. Common, and Dr. Gill. Among these the star photographs by the Brothers Henry, a photograph of a sunspot by Dr. Janssen, in which the minute structure of the penumbra and bridges of a large sunspot were exquisitely shown on a scale of something like 10 feet to the solar diameter, and two exquisite photographs of Saturn, enlarged eleven times, by the Brothers Henry, excited the greatest wonder.

The Solar Physics Committee sent a collection of the daily solar photographs which they are now obtaining from India and the Mauritius to supplement the Greenwich series. These photographs are on scales of 12 inches or 8 inches to the solar diameter.

Mr. Norman Lockyer exhibited some photographs of spot spectra showing the widening of the lines and the reversal of H and K; and also some photographs illustrating the first results of a new branch of work recently undertaken at South Kensington, in which it is hoped eventually to obtain photographs of the spectrum of the chromosphere and prominences without an eclipse. The photographs showed that the bright lines H and K have already been caught. Mr. Lockyer also exhibited the new split-grating spectroscope recently described at the Royal Society; the green line of lithium being shown between the D lines.

Nor must we forget to mention a selection of drawings of the sun on a large scale from those now daily made at Stonyhurst College Observatory; these were exhibited by the Rev. S. J. Perry. Special care has been devoted to the faculæ, which are drawn with a red pencil, and their position is as accurately determined as that of the spots.

Mr. Howard Grubb exhibited a model of an equatorial and observatory which he has proposed for the 3 foot refractor for the Lick Observatory. All the required motions of the telescope, dome, and rising floor are effected by water power (represented here by clockwork) governed by an electrical arrangement, the commutator being portable and carried by observer. By this arrangement the necessity of assistants, even in case of the largest sized instrument, is obviated, and the observer himself can, from any part of the observatory, control all the motions of instrument and dome without using any physical exertion.

Even observatory clocks were not neglected. Dr. Leonard Waldo, of Yale College, U. S., exhibited a gravity escapement adapted for use in a precision clock, in which the escapement lifts the gravity arms with a gradually increasing velocity, and with more certainty than in the ordinary forms; and a new astronomical clock.

Finally, the Eclipse Committee of the Royal Society were represented by charts of the West Indies and of the island of Grenada, showing the path of the total eclipse of August next, arrangements to observe which are now being made.

In pure physics the *piece de resistance* was the color photometer, for comparing the luminosity of colors and for testing the perception of color, exhibited by Capt. W. De .W. Abney and Major-General Festing. The form exhibited was an improvement upon the original one, which was fully described in *Nature* a little time ago.

Two exhibits by Mr. A. Stroh, also optical, may next be referred to. The first was an apparatus for showing stereoscopic effects on a screen; the next was an instrument for enlarging the angular division by means of reflectors, and thereby causing an object to be seen in exaggerated relief.

Electrical science was represented by the following new electrical apparatus exhibited by the Electrical Power Storage Company: (1) various types of cells; (2) ring contact switches; (3) automatic switch, for closing the circuit when the dynamo is running at the required speed, and for breaking it in case of accident; (4) hydrometers, specially for use with the company's cells; (5) pocket voltmeter for cell testing; (6) automatic switch to cut out two or more cells when dynamo is started, to keep constant electromotive force on lamps.

In addition to these there were the following, contributed by Messrs. Woodhouse & Rawson:

(1) Assortment of incandescent lamps, showing the latest developments in connection with the manufacture of incandescent lamps. (2) Small arc lamps giving 200 to 300 c. p. or more if required, specially designed for being connected upon the same circuit with incandescent lamps of ordinary c. p., and being run by the same dynamo. These lamps can be also wound for running in series. (3) Switch-boards, illustrating the universal system introduced by Messrs. Woodhouse & Rawson. (4) Electric lighting switches and safety junctions, for manipulating currents of from 200 to 500 amperes and upward.

Mr. Pitkin exhibited some very interesting portable electric lamps intended for use in coal mines and powder magazines. A small teak box contains three or more accumulator cells, which, when charged, give a continuous light for ten hours. In a modified form of the invention, the lamp is detached from the box containing the accumulators, and is electrically connected by means of a flexible cord; by this arrangement a very convenient railway reading lamp is formed, as the box can be placed under the seat or on the rack, and the lamp itself either held in the hand or hooked to the back cushions or to the button hole of the coat of the reader in a convenient manner.

A new electrical influence machine, having eight disks working within a glass case, was exhibited by Mr. Wimshurst.

Electricity applied to meteorology was represented by an electrical wind vane and indicator exhibited by Mr. F. M. Rogers. This instrument enables the direction of the wind to be ascertained at any moment, and at any reasonable distance from the vane, within a house, observatory, or office. One vane will actuate several receivers, which are quite independent of each other. Should the vane remain for many hours upon any one point, no waste of current takes place; the expenditure of such being limited to the momentary impulse required to effect change of direction upon the dial of receiver.

Messrs. De la Rue and Hugo Müller showed how the chloride of silver battery could be applied to electric lighting by a quantity arrangement. Instead of using a solution of chloride of ammonium simply, the solution, containing 2½ per cent. salt, is converted into a vegetable jelly, by dissolving in it Ceylon moss (agar-agar) to make a stiff jelly; this supports the zinc plate. The chloride of silver in *powder* is spread evenly on the bottom of the dish, on which a piece of silver foil is placed.

One of the most interesting exhibits was by Mr. Conrad Cooke, C.E., who showed Dr. Auer von Weisegg's incandescence system of burning gas. A small Bunsen flame burning about 2½ feet of gas per hour gave a dazzling light of about twenty candles by suspending in it a gauze cylinder which had been impregnated with the salt of a rare earth (probably zirconium). Tested by the spectroscope, the light showed a large excess of blue rays as compared with an ordinary gas-flame.

Voltaic cells with solid electrolytes were exhibited by Mr. Shelford Bidwell.

Great excitement was caused among the chemists by the specimens of the new element germanium and some of its compounds, from Prof. Winkler, of Freiberg, brought by Dr. Hugo Müller. These were:

(1) Metallic germanium; (2) germanium monosulphide, GeS; (3) germanium disulphide, GeS_2; (4) crystallized germanium, obtained by the action of hydrogen on germanium sulphide.

Germanium is claimed to be the ekasilicium predicted by Mendelejeff in his periodic law.

	Mendelejeff's ekasilicium.	Germanium.
Sp. gr.	5·5	5·469
Atom. weight	72	72·75
Atom. val.	13	13·3

Mr. G. J. Symons exhibited a small pocket thermometer as constructed by Immisch. This thermometer is actuated by a minute Bourdon tube. It is shaped like a watch, is watertight, and nearly unbreakable.

A terrestrial globe showing magnetic meridians for the epoch 1880, and general distribution of the secular change of the declination, made for the Hydrographic Department of the Admiralty, was exhibited by Staff-Commander Creak, R.N. The approximate positions of the foci of greatest secular change of the declination and vertical force—except for the Arctic and Antarctic zones—are also shown. A consideration of these foci shows the general angular motion of the north or marked end of a freely suspended needle as regards secular change.

The fact that our space is nearly exhausted, although we have only referred to about one-half of the exhibits, well indicates the care taken to make the *soiree* a success. In conclusion, we refer as briefly as possible to some of the remainder:

Jordan's photographic sunshine-recorder, with specimens of observations, exhibited by Mr. J. B. Jordan, of the Mineral Statistics Branch, Home Office.

Original geological map of the Orange Free State, and section of part of Cape Colony, by the late G. W. Stow (unpublished), exhibited by Prof. Rupert Jones, F.R.S.

Specimens of daily synchronous charts of the North Atlantic for the period of thirteen months, from August, 1882, to August, 1883, inclusive, now in course of preparation by the Meteorological Office, exhibited by the Meteorological Council. The specimens show the meteorology of the North Atlantic on three summer and on three winter days.

New and interesting plants, exhibited by the Director of the Royal Gardens, Kew.

Nolls' apparatus for demonstrating secondary growth in thickness of stems; Hopfe's Collectiones Phytomicrotomicæ, exhibited by Prof. Bayley Balfour, F.R.S.

Collection of stone-headed arms, implements, etc., from New Guinea, exhibited by Mr. H. B. Brady, F.R.S.

Diagrammatic sections showing the geological structure and physical features of parts of Arabia Petræa and Palestine, exhibited by Prof. Edward Hull, F.R.S., Director of the Geological Survey of Ireland: (1) from the sea-coast at Askalan by Jerusalem to the Jordan Valley at Jericho; (2) from the tableland of Southern Judæa—across the Dead Sea to the Plains of Moab; (3) from the Gulf of Suez, near Tor, by the Mountains of Sinai, to the Plateau of Badiet et Tih.

Apparatus for measuring the luminosity of leaves, invented and exhibited by Dr. Gorham, to show that the white light reflected from leaves can be measured in *cents.* of a circle by the novel use of a *gray ring*, and that by putting this luminosity in the form of an equation its equivalents in color are discovered, which, when placed in sectors on a circular disk and rapidly rotated on a wheel, are seen to match the color of the leaf from which the luminosity has been originally reflected.

Specimens of miners' electric lamp, invented and exhibited by Mr. Swan.

Dr. Sohlberg's celestial globe of glass; Dr. Schmidt's tellurium; cosmographic clocks for showing universal time; contoured map of the English Lake District, constructed by Mr. Jordan; enlarged original photographs taken by Mr. Joseph Thomson in his recent journey up the Niger; replica of Frankfort globe, of date 1520; two large diagrams: (1) Roraima, British Guiana, by Mr. Im Thurn; (2) a similar formation in the north of Brazil, by Mr. Wells; collection of minerals from summit of Mount Roraima, exhibited by the Royal Geographical Society.—*Nature.*

CARBONIC ACID AS A FIRE EXTINGUISHER.

REFERRING to our recent article on the use of carbonic acid in case of fire at sea, a correspondent calls our attention to Johnson's ingenious gas holders, devised more especially for the protection of safes and vaults. The highly compressed carbonic acid is contained in seamless steel holders and confined by fusible metal plugs, which will melt at any given degree of heat. These reservoirs are placed both on the outside and in the interior of the safe. In case of fire, the high temperature—which need not reach the boiling point of water, to melt a certain class of alloys—causes the melting of the fusible plugs, and the carbonic acid fills the interior of the safe and the surrounding space. The sudden expansion of the gas produces an intense cold. The safe is consequently reduced to a frigid temperature, and at the same time is filled and surrounded with a gas fatal to combustion. The pressure of the gas in the interior of the safe would also prevent the entrance and condensation of steam, which is a frequent cause of destruction to valuable papers and goods otherwise uninjured by the fire.

Carbonic acid possesses so many qualities which make it eminently available as a fire extinguisher, and under certain conditions is so very efficient, that an extension of its use is highly to be recommended. It can be generated on the spot with ease and rapidity. When stored in strong cylinders, it occupies but little space, owing to its ready compressibility, and with the turning of a cock, or the action of some automatic device, such as the fusible plug, may be poured upon the fire as soon as discovered. It is an entirely inexplosive gas, the only care necessary in this respect being the ability of the reservoirs to withstand the strong internal pressure. It is as fatal to animal respiration as it is to the oxidation of the burning goods and buildings, and its use must naturally be avoided in any confined spaces, such as cellars or the hold of a vessel, until it is certain that all the people have been rescued from such a position or are beyond hope of recovery.

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